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Decorative Design.

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THE TECHNICAL EDUCATOR:

BEING THE TECHNICAL SERIES OF "CASSELL'S POPULAR EDUCATOR."

PHOTOGRAPHY.—I.

By J. C. Leake.

INTRODUCTION—PROCESSES—COLLODION PROCESS—PHOTOGRAPHIC CAMERA—PRACTICAL DETAILS OF WORKING—DARK CHAMBER.

The scientific art of photography, although of recent introduction, is of such great importance, and is so extensively employed in all branches of science, art, and manufactures, that a technical education can scarcely be considered as complete without a knowledge of it. The services rendered by so ready, simple, and accurate a method of recording facts, and of copying scenes from nature, drawings, or machinery, can scarcely be over-estimated; and the importance of the art may at once be judged from the fact that the governments of most countries consider it advisable to train a special body of men as photographers, that they may accompany any military expedition of importance, and by its means record any noteworthy events of the campaign. Under these circumstances we propose offering in these pages such instruction as may enable our readers to secure photographs of any scenes or objects of which copies may be required. But it is necessary to observe at the outset that our instructions should be followed implicitly in the first instance, and that no modifications of the process about to be described should be attempted until the operator is well grounded in what we may call the standard method of producing pictures. Of this there are many modifications; but these had better be left alone until complete success has been attained by means of the processes and formulæ which will hereafter be given, and which may be considered good and reliable in every particular. If this care be exercised, there need not be any difficulty in producing excellent pictures; but at the same time it must not be supposed that the art consists merely of pouring over glass plates certain chemical solutions; much tact and skill are necessary when really good work is required, and in many cases these qualifications will be taxed to the utmost extent. Above all things the utmost cleanliness is absolutely necessary; not the mere outward cleanliness of every-day work, but chemical purity of all the materials employed. For instance, a glass plate may be apparently clean and bright, while it is in reality so dirty as to be perfectly useless for photographic purposes. The merest speck of dust, or slightest trace of grease upon the glass, will produce spots and stains of such a character, as to render the photograph practically useless. Again, in the case of water employed in certain parts of the process, it is useless to direct the use of that which is merely clean: it must be pure, that is to say, it must be chemically clean. It cannot be too distinctly understood that in the various photographic processes chemical changes are involved which are of the most extreme delicacy, and that consequently the utmost care is requisite in order to exclude any extraneous substances which might interfere with the proper combinations and reactions of the chemicals employed. With these few preliminary remarks we may at once proceed to the practical details of our subject.

Although there are almost numberless processes and modifications of processes known to photographers, there is one which, for all practical purposes, is unrivalled as well for simplicity and certainty, as for beauty and delicacy of the resulting pictures. This is termed the "collodion process," and, as may be surmised, the impression is produced upon a film of collodion, which is supported by a plate of glass. This may be fairly called the standard process of photographic art, and at least nine-tenths of the photographs produced are made by means of it. Discovered and invented by Mr. F. Scott Archer in 1851, it still remains almost as its inventor left it in all important particulars, the nearest approach to a perfect photographic process to which we have yet attained.

The employment of a film of collodion to support certain salts of silver which are sensitive, and may be acted upon by light, may be considered almost as the starting point of practical photography, as so ready and certain a method had never before been introduced. Chemically the collodion film is inert, and plays no part in the actual production of a picture; it is merely the medium or vehicle which holds in solution the active chemical ingredients required. Collodion is a solution in alcohol and ether of a substance almost identical with gun-cotton, and which is termed pyroxyline; upon the evaporation of the solvents it leaves a thin transparent film of a tough character, closely resembling gold-beaters' skin. To a solution of the plain collodion are added certain salts called iodisers, such as the iodides of potassium, cadmium, or ammonium, and in the case of bromo-iodised collodion one or other of the bromides, after the addition of which the collodion is termed iodised. When a portion of this compound is poured over and spread upon a plate of glass, a certain quantity of the iodising salts are of course retained in the film, which is then totally insensitive to light. In order to render it capable of receiving an impression in the camera, the iodised film must be immersed in an aqueous solution of nitrate of silver, which combining with the iodides and bromides contained in the film, forms a layer of iodide or bromo-iodide of silver of the utmost delicacy and sensitiveness to the action of light. It is scarcely necessary to observe that the sensitising and all subsequent processes up to the time of fixing the image, must be performed in a room which is protected from the action of the actinic rays, as we shall presently explain. When the plate has thus been prepared, it is ready for exposure to the action of light in the camera.

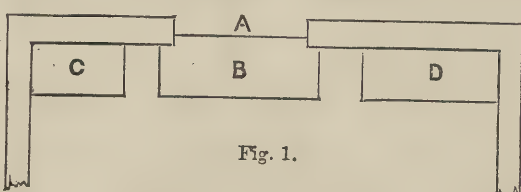


Fig. 1.

The photographic camera is simply a box of wood or other opaque material, into one end of which is fitted a lens of a suitable character, and capable of projecting upon the sensitive surface an image of any object before which it is placed. At the reverse end of the box is fitted a screen of ground-glass, which is used for the purpose of adjusting both the position of the image upon the plate, and the distance of the lens from the sensitive surface, in order that it may be rendered perfectly sharp and distinct. A case or box having a sliding door is also made to fit into the same groove as the screen, and is intended to hold the sensitive plate during the adjustment of the camera. When this adjustment has been made, the box or slide containing the plate is inserted in place of the screen, and the shutter having been drawn up, the exposure of the plate to light is continued for the requisite time; after which it is removed to the operating-room for development.

Upon the removal of the plate from the camera, no trace of a picture is visible; but the latent image is rapidly developed upon the application to the sensitive surface of a solution of sulphate of iron or of pyrogallic acid. The picture thus produced, however, possesses this peculiarity, that all the lighter

parts, such as the sky, are in the negative dark; while the darks are light or transparent: the whole of the gradations from extreme light to dark are thus reversed, the various shades being perfectly rendered by half tints. It is from this negative that copies with their lights and shades in their proper order are produced by the printing processes hereafter to be described. But as the sensitive film has only been darkened, and not actually removed by the action of light, it is necessary to remove the remaining sensitive salts from the picture before exposure to diffused light, in order to prevent a general darkening over the whole surface, which would, of course, obliterate all trace of a picture. This operation is called the "fixing process," and it is effected by flooding the plate with a solution either of hyposulphite of soda or of cyanide of potassium. Either of these salts will quickly remove the unaltered portions of the sensitive surface, and render the picture permanent and unaffected by the further action of light. Chemically the negative is now completed; but as the film forming the picture is one of exceeding delicacy, and is easily scratched or destroyed, it is necessary to coat it with a suitable varnish in order to protect it during the operation of printing.

With this brief outline of the collodion process, we may at once proceed to the practical details of working. For convenience of description we will suppose the photographer to commence his experiments at home, or at some place where the two great requisites, plenty of water and a convenient laboratory, are to be obtained. The laboratory should be a clean room fitted with shelves, several tables—if possible, a sink with a good supply of water laid on over it—and not more than one window of moderate dimensions. In order to render this room fit for photographic purposes, it will be necessary to exclude all light except that which passes through a yellow medium, which must be sufficiently dense to exclude all the actinic rays. A ready and cheap method of effecting this purpose is as follows:—Procure a light frame of wood, of such dimensions as may be required to completely cover the window opening. Upon this should be stretched at least four thicknesses of common yellow calico; the whole may then be hinged at the top or one of the sides of the window, as may be most convenient, taking the utmost care to exclude the smallest ray of white light, which would inevitably spoil the sensitive plate. It is well to have this screen easily removable, in order that an abundance of light may be readily admitted into the room while such portions of the process as may be performed in ordinary daylight, such as coating the plate and fixing after development, are in course of execution. The arrangement shown in Fig. 1 will give some idea as to the proper fitting of the developing-room or laboratory. In this A represents the window, immediately underneath which should be placed the sink B, or in default of this a table or shelf capable of supporting a suitable vessel for catching the waste developing solutions, and the water used for washing the plates. If possible the water should be laid on over this sink; the space marked C should be occupied by a strong table, to be used for the purpose of supporting the nitrate of silver bath required for the preparation of the sensitive plate. Over this a shelf or two should be erected, upon which the necessary chemicals may be kept so as to be within easy reach. Upon the opposite side of the sink, in the space marked D in the diagram, should be placed a similar table to that before mentioned, which should be used exclusively for the fixing process. This is important, as the smallest trace of the fixing agent usually employed, the hyposulphite of soda, would, if introduced at any of the earlier stages of the work, prove fatal to any hope of success. If photographic operations are to be carried on through the winter season, it will be necessary to have a stove in the room; and as a rule those in which gas is burned should be avoided, in consequence of the noxious fumes evolved. A close stove with an ordinary pipe chimney will answer every purpose, and is on the whole the most suitable for the situation. A cheap thermometer suspended in the room will be found to be most useful, as many failures may be traced to the fact of the temperature being too high or low. It is hardly necessary to observe that the operating chamber must be kept absolutely clean, and free from dust and dirt of every description. If the highest success be desired, the best of good order must be observed in all the arrangements of the laboratory, and a sufficient supply of soap and towels should be so placed as to allow of the hands of the operator being rinsed and dried at the conclusion of each part of the process. All bottles containing chemicals and solutions should be kept strictly in their places, and so conspicuously labelled as to be readily recognised even in the dull light which will, of course, prevail. Finally, upon no account must the slightest disorder be allowed in any particular, or the operator will speedily find himself involved in troubles and difficulties of every description.

The preparation of the dark chamber is a matter of the first importance, and consequently we have described it at considerable length; while although it must be done by each operator for himself, it cannot be correctly classed with actual photographic operations. For this reason we shall here conclude the present chapter, and in our next proceed to describe the various processes necessary in order to produce photographic pictures, as well as the apparatus required for the same purpose.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXII.—JOHN RENNIE, ENGINEER.

BY JAMES GRANT.

JOHN RENNIE, who may justly be considered as among the first, if not the first, of that great school of practical engineers which has been established in Great Britain, was the son of a respectable Scottish farmer, and was born at the homestead of Phantassie, in the parish of Prestonkirk in Haddingtonshire, on the 7th of June, 1761. In his fifth year he had the misfortune to lose his father, but his education was carried on at the parochial school by his mother and her family. Young Rennie's peculiar turn for mechanics and invention seems to have been fostered by his vicinity to the workshop of Andrew Meikle, an eminent millwright, the inventor or improver of the threshing-machine, who now lies in the humble churchyard of Prestonkirk, where his grave is marked by a handsome tombstone. In his frequent visits to Meikle's establishment, he was wont, boylike, to be "constantly occupied in using, and perhaps in abusing, the tools that fell in his way;" but as he advanced in years, he began to imitate at home, in the farmhouse of Phantassie, the models of machinery he had seen, and at the early age of ten had constructed those of a windmill, a steam-engine and pile-engine, in the last of which he is said to have exhibited much practical dexterity.

In his twelfth year, he was removed from the school of Prestonkirk, in consequence of some misunderstanding with the master, whom he had already begun to deem incapable of advancing him in his studies, and he entered the employment of Andrew Meikle, with whom he continued for two years; but finding his education deficient, in 1775 he went to Dunbar, where he studied mathematics under Mr. Gibson; and two years after, preferring mechanical employment, he returned once more to the workshop of Meikle. On his tutor Gibson being appointed rector of the Perth academy, he recommended young Rennie as his successor at Dunbar, where the future engineer taught the school for some weeks, but merely to oblige his friend, as he had no idea of teaching even mathematics as a profession.

Again he returned to Andrew Meikle, and employed all his leisure hours in modelling and drawing machinery, and so skilful did the lad become, that ere he had quite reached the age of eighteen, he had erected at least three corn-mills in his native parish; but the first work he undertook on his own account was the rebuilding of the flour-mills at Invergowrie, in Forfarshire. The energy with which he prosecuted his engineering labours in summer, afforded him sufficient funds to visit Edinburgh in the winter, and to attend the lectures of Dr. Black on practical chemistry, and those of Dr. Robison on natural philosophy, thus fitting himself for the profession to which he aspired, with honest and determined enthusiasm—that of civil engineer. By Professor Robison he was recommended to Messrs. Watt and Boulton at Soho, and on his way to that place he made a close and practical inspection of the Lancaster aqueduct, the Liverpool Docks, and the Bridgewater Canal; and after remaining some months at Soho, he travelled through the Yorkshire manufacturing districts, and finally settled in London in 1783.

At this time there occurred that which may be deemed an era in the history of the great manufacturing establishments of Britain—the erection of the Albion flour-mills in London.

Messrs. Watt and Boulton planned the scheme, but the construction of the two great steam-engines, and all the millwork and machinery connected therewith, were confided to John Rennie; and Watt has himself recorded, in a note to Robison's "Elements of Mechanical Philosophy," the valuable assistance which he derived from his young friend in those great works, which were eventually and wilfully destroyed by fire in 1791, when an ignorant mob, believing that monopoly was injurious to public good, thought to reduce the price of flour by an act of incendiarism.

"The Albion mills," says James Watt, "consisted of two engines, each of fifty horse-power, and twenty pairs of millstones, of which twelve or more pairs, with the requisite machinery for dressing the flour and other purposes, were generally kept at work. In place of wooden wheels, always subject to frequent derangement, wheels of cast iron with teeth truly formed and finished, and properly proportioned to the work, were here employed, and other machinery which used to be made of wood, was made of cast iron in improved forms; and I believe the work executed may be said to form the *commencement* of that system of millwork which has proved so useful to this country."

Mr. Samuel Wyatt designed and executed the buildings; but the superior mechanism of the Albion Mills brought Rennie prominently under the notice of the public, and he soon obtained extensive employment in the construction of sugar-mills for the West India planters; and as his circumstances were fast improving, in 1789 he married.

He constructed the machinery of the powder-mill at Tunbridge, of the flax-mill at Wandsworth, of the rolling and triturating mills of the Mint in London; of Messrs. Whitbread's brewery, and many other breweries and distilleries; and the year 1794 saw him regarded as the head of the profession of civil engineers in Great Britain, and in connection with every public work of importance in the United Kingdom. In all the millwork erected by Rennie, there was one remarkable improvement that was strictly his own idea. "It was formerly usual to place the vertical axis of the running millstone in a bush, placed in the middle of the horizontal bridge-tier, which was supported only at its two extremities. The effect of this was that the bridge-tiers yielded to the variations of pressure arising from the greater or less quantity of grain which was to be admitted between the millstones, which was conceived to be a useful effect; but Rennie made the bridge-tier perfectly immovable, and thus freed the machinery from that irregular play which sooner or later proves fatal to every kind of mechanism."

Rennie was celebrated for architectural taste, as well as engineering skill. The design of the aqueduct bridge over the Lune, at Lancaster, has been ascribed to him. Among his works were the stone bridge of Kelso, which was commenced in 1803, and finished in two years, at the cost of £18,000, and which is 494 feet long, with five elliptical arches; that of Leeds, to which he added an additional arch, 100 feet in span above the Aire; a third at Musselburgh, built across the Esk in 1807, superseding the use of the old Roman bridge which still survives; a fourth of granite and freestone at Newton-Stewart above the Cree in Galloway, a handsome edifice consisting of five arches; a fifth at Boston, consisting of one elegant arch, which crosses the Witham, superseding a very inconvenient and plain one of wood; and a sixth at New Galloway across the river Ken, all of which sufficiently testify his taste and skill in the art of bridge-building.

He was employed by the Indian Government to design a bridge of three arches, consisting respectively of seventy, eighty, and ninety feet span, to cross the Goomtee at Lucknow; but after it had been cast, constructed, and sent out, the Nabob of Oude, inspired by some whim or caprice, would not permit its erection.

Rennie's celebrity as a bridge-builder must always be attached chiefly to his Waterloo Bridge over the Thames, which is certainly one of the finest monuments we possess of British enterprise and architectural skill; yet he was accustomed to boast that, although a humbler effort, "he considered the bridge of Kelso as one of the very best which he ever designed." The former stupendous work, which was completed in 1817, has not altered more than five inches from a straight line in any part of it. His design for a bridge where old London Bridge formerly stood was selected by the committee as the best of thirty plans submitted to them, and of which many were sent in by architects of the highest merit. This bridge, which was completed by Sir John Rennie and his brother George from their father's designs (for Rennie himself did not live long enough to see them executed), consists of five arches of Aberdeen granite, the central one having a span of 150 feet. He was also the architect of the Southwark iron bridge, which was opened for traffic in 1818.

Among those canals which he personally superintended, we may mention the Lancaster canal, the Aberdeen, which connects the Dee and Don, the Grand Western, the Kennet and Avon, the Birmingham, the Portsmouth, the Worcester, and several others. Besides plans for the West India Docks at London, he executed others for the construction or improvement of docks at Hull, Greenock, Leith, Liverpool, and Dublin; together with harbours at Berwick, Dunleary, Holyhead, Howth, Newhaven, the Queen's Ferry on the Forth, and some others, the mere enumeration of which would prove tedious. In addition to these useful naval works, he designed various important improvements at the Royal dockyards at Portsmouth, Sheerness, Chatham, and Plymouth, and the new naval arsenal at Pembroke was constructed from his plans; but the greatest of all his works is unquestionably the Breakwater at Plymouth, a description of which would far exceed the limits of this brief memoir. Suffice it to say, that it consists of three continuous parts, a centre of 1,000 yards in length, with two wings of 350 yards each, diverging from the centre at an angle of 20°. The low-water line is, however, one mile in length. The top is 45 feet broad; about 500 yards of the central division rests on the Shovel Rocks. The anchorage within has fine holding ground, and a depth at low-water spring-tides of from 5 to 7 fathoms. According to the original estimate of Rennie and Whidby, 2,000,000 tons of stone were required to complete the plan; but by 1841 more than 3,500,000 tons had been deposited: the original estimated cost was £1,013,900.

He made a design for a new naval arsenal at Northfleet, on the Thames; but the sum of eight millions required for the work was considered by Government as too great to be expended upon it. In addition to this somewhat bare enumeration of Rennie's useful and scientific labours, we may add his drainage of the tracts of marsh lands on the borders of the Trent, the Witham, and New Welland, and his plan for draining the Bedford Level, which was but partly carried into execution. "These various public concerns (to quote Brewster's Encyclopædia) are said to have cost little less than fifty millions sterling, nearly twenty millions of which were spent under his own superintendence."

Although Mr. Rennie was of a robust and fine commanding figure, and of corresponding strength of constitution, yet during the latter years of his life he was afflicted with inflammation of the liver. On going to France in 1816, after Waterloo opened up the Continent to British tourists, he declared it was the first relaxation he had taken for thirty years. The disease under which he laboured began ere long to assume a more serious form, and he died in his sixtieth year on the 16th of October, 1821. His remains lie in St. Paul's, near those of Sir Christopher Wren, and under a plain granite slab. Many biographies have appeared of him since then, and a eulogy, soon after his death, was written upon him by M. Charles Dupin. An excellent bust of him was executed by Chantrey, and two able portraits were painted by his countryman, Sir Henry Raeburn, President of the Scottish Academy.

His plans for the improvement of Sheerness, and the final construction of New London Bridge, were ably carried out, as already stated, by his sons George and John, afterwards Sir John Rennie, who was knighted on the opening of the latter work in 1831, and who, up to the time of his death in 1874, was so well known in connection with many railway operations, the drainage of the Lincolnshire coast at the Wash, the construction of new docks at Whitehaven, the harbour at Ramsgate, and other similar works of equal magnitude.

In closing this sketch, it should not be forgotten that George Rennie, brother of the great engineer, was one of the most eminent of Scottish agriculturists, the chief patron of Meikle—who invented the drum threshing-machine, a useful discovery claimed by more than one person—and his reputation as a successful and scientific farmer was known over the whole of Scotland, and formed an incentive to the most intelligent agriculturists in that kingdom.

OPTICAL INSTRUMENTS.—XIV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

The Lime-Light.—Next in importance to the electric stands the "lime-light," so called because it emanates from a ball, cylinder, or tablet of lime, rendered *incandescent* by means of a jet of oxygen blown through the flame of a spirit-lamp, or a house gas-burner, or by an ignited mixture of oxygen and hydrogen gases. When the first method is employed, it may be distinguished as the oxy-spirit jet; and when the second is used it may be called the oxy-house-gas jet; both of these, however, are usually known as the "oxy-calcium light." The third method is called the "oxy-hydrogen light," whether pure hydrogen or carburetted hydrogen (house-gas) be employed.

The lime-light has also been called after the names of persons: thus we have the "Drummond light," through Lieutenant Drummond having employed it in 1826* for signalling while conducting the Ordnance Survey of Ireland and Scotland. When the two gases are *mixed* in a bladder or other receptacle, it is called "Gurney's apparatus;" when the gases are condensed in metal reservoirs, it has been called "the Fitzmaurice light." Then we have the "Bude light," likewise invented by Gurney, where a little ball of lime is suspended over the flame of an argand burner by a platinum wire, supported and rendered incandescent by a jet of oxygen impinging on it, though this name is also given to a simpler arrangement, wherein oxygen under low pressure is passed into the centre of an argand burner fed with highly carbonised oil. Most substances fuse, melt, and are vaporised under the high temperature of the oxy-hydrogen blow-pipe; but lime is one of the few bodies that remains infusible under its action, when it becomes so intensely and luminously incandescent, that the unprotected eye cannot bear to look on it for any length of time. As the ignited mixture of oxygen and hydrogen gives but a feeble blue light, and the true source of light is the lime itself, it is palpable that the most correct generic term for all such arrangements must be the "lime-light," and not "oxy-calcium" or "oxy-hydrogen" light, as we frequently see it called. The lime-light is intensely brilliant, and so purely white in tint, that objects appear in their natural colours, as when seen by day. It is free from all unpleasant or deleterious exhalations, and as no chimney-glass is employed, its heat, like that of the electric light, is diffused into the surrounding atmosphere, so that when confined in a lantern or other apparatus no inconvenience is experienced from the furnace-light heat that argand burners give rise to. As this light is due to incandescence and not to combustion, it may be confined in air-tight glass vessels for use in mines or under water, and as it is not dependent upon a surrounding atmosphere for a supply of oxygen, it consequently presents hygienic advantages if employed in the illumination of buildings, factories, art galleries, etc. The manipulation of the light itself is simple and cleanly, the drawback, in this country, being the necessity for preparing the gases, or at least the oxygen. In Paris and America both oxygen and pure hydrogen are prepared on a large scale, and supplied to the public at a very cheap rate, while in New York oxygen can even be laid on to the houses, where desired, in the same way that we treat carburetted hydrogen, not only for improving illumination, but for sanitary purposes, to neutralise the miasma of fevers, etc. In places where the gases are made on a large scale, the cost of working lime-light apparatus would be insignificant; nor for the intensity of the light obtained, can this source of light be regarded as expensive, even when the gases have to be made at home. I will proceed to describe the component parts of the lime-light apparatus, which embraces the lime cylinder, hydrogen and oxygen gases, their receptacles, the jet, and safety arrangements.

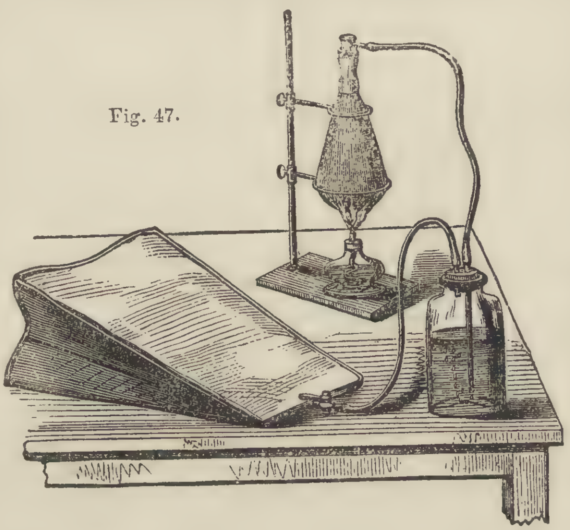


Fig. 47.

Lime cylinders are of two qualities, "soft" and "hard." The first is made of ordinary unslacked lime (chalk lime), and is best suited for oxy-calcium jets, with which a lower pressure of oxygen gas is employed; the second is made from magnesian limestone, and is used with the mixed gas jet when high pressure is employed. Soft limes are turned into cylinders of about $\frac{3}{4}$-inch diameter, and $1\frac{1}{4}$ inch in length. Hard limes are about 1 inch in diameter and $1\frac{1}{2}$ in length. Through the exact centre of each cylinder a hole is drilled, by which it is fitted to the lime-pin of the jet. It is very important that these cylinders should be turned quite true and of a given gauge, such as those given, as it saves a great amount of adjustment when in use. Both soft and hard limes are hygroscopic, or possess a strong affinity for damp, and therefore are very subject to "slack," that is, imbibe moisture, swell, and then break up into slacked lime. It is best, therefore, to preserve lime cylinders in air-tight cases, all vacant spaces being filled up with dry washed sand. Even when packed in metal tubes, just a size larger than the diameter of the lime cylinders, closed with screw-caps and metal "washers," I have known the limes to swell from previously imbibed moisture, and burst the tubes; and it is a very common thing to find the ordinary tin canisters in which a dozen cylinders are sent out from the shops, burst open at the soldered joints, if put aside for a time without having taken the precaution to warm the limes and powder, and paste a strip of paper round the edge of the lid. The preservation of limes is an important question, especially when a large stock has to be sent abroad, and the recipients would be placed *hors de combat* for some months, should the cylinders "slack." The best and simplest way to meet the danger is, I find, to warm *freshly-turned* lime cylinders, and then, in a dry room, wrap each in a strip of waxed paper (made by melting a wax or paraffine candle over a sheet of thin foreign letter paper, and spreading it evenly over the surface with a flat iron), and turning in the ends so as to make an air-tight casing, then to wrap up half a dozen of these in a cylindrical roll of waxed brown paper, and pack them in flat tin cases, large enough to hold a gross or half a gross of cylinders thus preserved. A neat way to preserve small quantities, say a dozen, when freshly purchased, is to suspend them by a thread, and dip each into a solution of india-rubber in benzole; the spirit quickly evaporates, and leaves a thin covering of caoutchouc, which effectually preserves each cylinder, if properly done.

Stout brass tubes, with deep screw-caps and tin-foil washers, make the best and neatest lime-boxes. This tendency to slake has induced experimenters to seek other suitable substances. Magnesia mixed with plaster of Paris, worked with water into a smooth paste, and cast in wooden moulds, and then baked, has been recommended; but even when these have been hardened by bi-silicate of potash being added to the water, I find such cylinders do not stand under the oxygen jet. Meerschaum, a silicate of magnesia, answers better, but the drawback is that it produces a pinkish tint when rendered incandescent. Magnesia, rendered perfectly pure, and condensed into a small compass by means of the hydraulic press, has been used in France by M. Tessié du Mothay, but specimens I have tried "pit" deeply and quickly, on being subjected to the ordinary pressure employed with English jets. Probably, if the magnesia

* The lime-light was employed as far back as 1820.

were compressed as thoroughly as chemical compounds are capable of being condensed by Brockedon's patent process, this defect would be surmounted, but the apparatus required is of a costly description, and that in existence is now not in work.

Monckhoven has recommended compressed cubes of magnesia containing embedded titanate of magnesia, which I have tried, but cannot say I feel impressed with their great superiority. Monckhoven states that "a compound made up of 10 parts of pure carbonate of magnesia, 2 of charcoal, 1 of chloride of titanium slightly damped, worked in a mortar, and compressed into pillars, gives a light almost twice as brilliant as the one above described, but costs ten times the amount." M. Soret has invented an artificial stone of great hardness, which would probably answer admirably for lime cylinders. It is an insoluble compound of chloride of magnesium and magnesia, formed by combining calcined magnesia with a saturated solution of chloride of magnesium, and allowing it to set in moulds. Du Mothay has lately introduced small discs of zirconia embedded in cylinders of clay or other cheap infusible supports. Oxide of zirconium is the most infusible, the most unalterable, and the most luminous of all the chemical substances at present known, when exposed to the action of the oxy-hydrogen jet; so it is in this direction we must look, in the hope of surmounting the drawbacks connected with the hygroscopic character of lime. I may here state that, though such preparations might at their first purchase seem costly, they would in the long run prove the most economical,* and be the greatest boons and comforts the lecturer could secure. Du Mothay thus describes his method of preparing zirconia:—"To obtain zirconia in a commercial state, I extract it from its native ores by transforming by the action of chlorine in the presence of coal or charcoal the silicate of zirconium into double chloride of zirconium and of silicium. The chloride of silicium, which is more volatile than the chloride of zirconium, is separated from the latter by the action of heat; the chloride of zirconium remaining is afterwards converted to the state of oxide by any of the methods now used in chemistry. The zirconia thus obtained is first calcined, then moistened, and submitted in moulds to the action of a press with or without the intervention of agglutinant substances, such as borax, boracic acid, or clay. The sticks, cylinders, discs, or other forms thus agglomerated, are brought to a high temperature, and thus receive a kind of tempering or preparing, the effect of which is to increase their density and molecular compactness. I can also compress in moulds shaped for the purpose a small quantity of zirconium capable of forming a cylinder or piece of little thickness, which may be united by compression in the same mould to other refractory earths, such as magnesia and clay."

For the purposes of photographic enlargements by means of the oxy-hydrogen jet, Professor Carlevaris of Genoa employs little cubes of retort carbon (such as is used with the electric light) saturated with chloride of magnesium; this produces a very actinic light when subjected to the oxy-hydrogen jet, but the chloride is quickly decomposed, and nothing remains but the ignited charcoal, so that this is not suited for a continuous light, though suited for short exposures in photographic enlargements. Should an exhibitor be awkwardly situated by finding his stock of limes injured by "slacking," he may meet the difficulty by getting a lump of quick-lime, and sawing it into cubes, then use one face after the other, sliding the mass up instead of round; or cylinders may be made by shaping the lime into hexagonal pillars, and then rounding off the edges with a rasp or coarse file. In either case the central hole may be made with "a rat-tailed file."

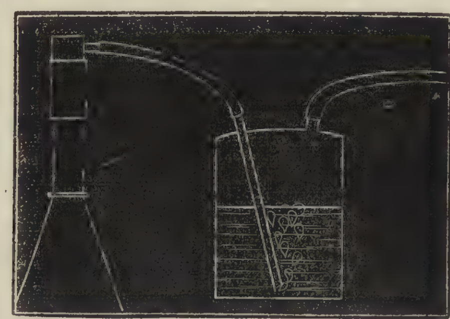


Fig. 49.

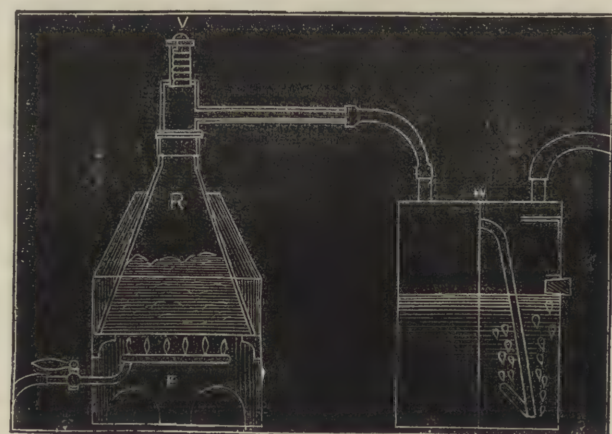


Fig. 48.

Oxygen Generating Apparatus.—Of the various methods employed for obtaining oxygen gas, the one most generally adopted is that of heating a mixture of chlorate of potash and oxide of manganese. In this process the oxygen is derived from the chlorate of potash, not from the manganese, which simply acts mechanically, not chemically, as sand, a non-oxygen producing body, may be used in its place. Practically, one pound of chlorate of potash yields four cubic feet of oxygen, though the text-books would lead us to look for a yield of five cubic feet from that quantity. Were we to treat the potash salt *per se*, the oxygen would rush from the retort with force: to subdue this violent action, we use the manganese, or any other suitable substance that will, as it were, mechanically dilute the mass of the potash salt; consequently a fixed proportion between these two substances is not essential, and may be varied from equal parts to 1 part of manganese to 4 of potash; though the proportion that allows the oxygen to come over neither too fast nor too slow, is 1 part of manganese to 3 of potash. If, therefore, we wish to produce six cubic feet of oxygen gas, we take a pound and a half of chlorate of potash, and mix with it half a pound of oxide of manganese. It is often directed to use the manganese in fine powder; this I found to be a grave mistake, as it tends to float on the surface of the melted potash, and on the oxygen coming over, it carries the fine powder in a damp condition into the delivering tubes, and blocks them. It is, therefore, better to use the manganese in coarse grains. The chlorate of potash should not be powdered, but left in its crystalline state, the larger crystals alone being broken, and then intimately mixed with the granular manganese. If the manganese is washed from the potash after each operation and then dried, it may be used over and over again, and apparently with advantage, as the oxide in its brown state after ignition seems to answer better than the original native black peroxide of manganese. Care must be taken that the mixture never becomes contaminated with organic matter in any shape, or it may lead to serious explosions. A few years back a death was occasioned by the manganese getting accidentally mixed with soot or some carbonaceous matter, and another explosion came to my knowledge (fortunately without serious result) through a small portion of india-rubber tube melting and running into the retort. In the ordinary method of manipulating, the mixture is placed in a conical retort (made of iron or copper), which is closed with a large vulcanised rubber tube that serves as a safety-valve; from this passes a tube that is connected with the dip-tube of a wash-bottle, as shown in Fig. 47.

On heat being applied to the retort, the gas passes over into the water in the wash-bottle, and is there freed from dusty particles and other impurities; on rising from the water, it passes out from the short exit-pipe into a gas-bag or other receptacle. In

* When the mixed gases are used under great pressure, clocks, to keep the lime in constant motion, are a necessity, but an indestructible cylinder would dispense with their use.

unpractised hands, this arrangement leaves the road open to certain mishaps. I have, therefore, re-arranged the oxygen-generating apparatus in such a manner as to provide against every contingency, a matter of importance when such appliances have to be provided for amateurs, who only use their apparatus a few times in the course of the year, and consequently cannot be reckoned on as practised manipulators.

My apparatus consists of a retort, a jacket-furnace, and a safety wash-bottle, shown in Fig. 48. The retort, R, may be made of iron or copper, conical in shape, with a flat bottom and wide neck, into which screws a brass cap fitted with a stout delivering-tube, and a safety-valve, V, formed of a tube, closed with a good cork covered with tin-foil, which, in the event of the delivering tubes becoming choked, yields and gives vent to the gas. The furnace, F, may be arranged for gas or charcoal, the former being the most convenient, as it allows of the amount of heat being increased or decreased at will, by the control of a stop-cock. It is made of sheet iron, and the upper part corresponds to the shape of the retort, which prevents a great amount of heat being dissipated, and secures the upper surface of the oxygen mixture being quickly melted as well as the substratum immediately over the flame. This corrects the evil arising from the tendency of the light particles of the manganese to float on the surface of the melted potash, previously referred to, which was the cause of the delivery-pipes becoming choked. After the mixture has become thoroughly melted, it not unfrequently happens that the oxygen comes over with a rush (especially if only a small allowance of manganese has been employed), instead of in a quiet, orderly manner, and then something may give way—it may be the safety-valve, or it may be the india-rubber connecting tubes, or the retort itself might "rip;" but by means of the stop-cock, or by lifting the furnace off the pan of charcoal, all violent action may be at once subdued; and by the same means provided in this arrangement, should the action become too torpid, it may be stimulated to the desired rate of delivery. Another source of accident arose, if the operator did not disconnect his retort from the wash-bottle as soon as all the oxygen was given off from the mixture; for nature, abhorring a vacuum, sucked up the water from the wash-bottle, and on its coming into contact with the red-hot residue, became converted into steam, and an explosion terminated the operation. This arose from the delivery-pipe of the retort passing directly into the water of the wash-bottle, as shown in Fig. 49.

To provide against this accident, I divide my wash-bottle into two compartments, and arrange the tubes so that the one connected with the retort does not come in direct communication with the water, as shown in Fig. 48. A shield at the exit-pipe of the wash-bottle prevents the spray being blown over into the gas-bag placed to receive the gas. This bottle is filled with water till it is two-thirds full. At this height a vent-hole, plugged with a cork, is placed, to allow of the bottle being emptied and cleaned out. The delivering-tubes should be about ½-inch in the bore, and the connections should be made with red-rubber tube, which stands the best, and is free from the unpleasant smell common to ordinary vulcanised india-rubber tubing.

TECHNICAL DRAWING.—XLIX.

GOTHIC STONEWORK.

GENERAL DIVISIONS OF ECCLESIASTICAL BUILDINGS.

In order that the position of the details forming the subjects of the following lessons may be clearly understood, it is necessary to explain some of the terms which are employed in relation to the churches or other buildings which exemplify them.

Most of the ecclesiastical structures of the Middle Ages were built in the form of a cross, with a tower or spire erected at the intersection. The interior was usually divided thus:—

The Nave.—The space westward of the central tower—the body of the church—reaching from the choir to the principal door. This name is applied equally to the body of the church, whether the plan is that of a cross or not, and whether with or without aisles.

The Aisles (from the French *aile*, "a wing").—The spaces outside the piers of the nave, choir, or transepts, and forming a passage or alley on each side of the nave extending to the outer wall of the building.

Choir.—The space eastward of the central tower—the continuation, as it were, of the nave on the opposite side of the base of the tower. In the early Christian churches it was simply part of the nave enclosed by a low wall, and forming a place in which the singers who chanted the services sat; hence the name (Latin, *chorus;* Italian, *coro;* French, *chœur;* German, *chor;* Old English, *quire*).

Transept.—That portion of a church which passes across the nave and choir, and thus forms the two arms of the cross in the plan, the central tower standing on the intersection. Commonly each arm is spoken of as a separate (as north and south) transept, although, strictly speaking, the transept is one. Transepts, in most instances, match each other exactly, or are in pairs. At Exeter are two noble Norman towers, which are supposed to have been the western towers that flanked the original Norman front. At Chester one transept is of Norman work, while the other is of the Decorated period, and is much elongated. It is supposed to have been built as a separate church, and it is thus used at the present time.

The choir is generally enclosed by a *screen*, on the western part of which is usually placed the organ; which is now, however, often placed on one side of the church.

The choir in cathedrals does not generally extend to the eastern part of the building, but there is a space behind the altar called the *Lady Chapel.* (The Lady Chapel is not always at the east end of the choir. At Durham it is at the west end of the nave, and at Ely at the north side.)

The choir is only between the piers, and does not include the side aisles, which serve as passages to the Lady Chapel, altar, etc.

Chancel.—A part separated from the rest of the church by a screen (*cancellus*). The term is now used to signify the choir of a small church.

The Apse.—The semi-circular or polygonal termination to a church. These forms were, no doubt, derived from the *concha* or *bema* in the classic and early Christian basilica.

Porches are covered erections, forming a shelter to the doors, which have sometimes vestries, schools, etc., over them.

Chapels are attached to all parts, and are frequently additions.

The Chapter House is the chamber in which the chapter, or heads of the monastic bodies, assembled (as the Dean and Chapter now do) to transact business. They are of various forms; some are oblong apartments, as Canterbury, Exeter, Chester, Gloucester, etc.; some octagonal, as Salisbury, Westminster, Wells, York, etc. That at Lincoln has ten sides; that at Worcester is circular.

Cloister.—An enclosed quadrangle, with a walk or ambulatory round it, sheltered by a roof generally groined, and by traceried windows, which were more or less glazed. Cloisters were used for exercise in bad weather, and for reading and meditation in the shade, when the season was hot. They also formed a covered communication between different parts of the monastery. The usual place for the cloister is the south side of the nave. At Canterbury, Gloucester, and Chester, however, they are on the north.

Any building above the roof may be called a *steeple.* If it be square-topped, it is called a *tower.*

The tower may be round, square, or multangular. It is often crowned with a *spire*, and sometimes with a short tower of light work, called a *lantern.* An opening into the tower in the interior above the roof is also called a lantern. When a tower is of great height, in proportion to its diameter, it is called a *turret.* These often contain staircases, and are frequently crowned with small spires.

Clearstory, or *Clerestory.*—When the middle of the nave of a church rises above the aisles, and is pierced with windows, the upper storey is thus called. Sometimes these windows are very small, being merely quatrefoils or spherical triangles. In large buildings they are important objects, both for beauty and utility. The windows of the clerestories of Norman work, even in large churches, are of less importance than in the later styles. In Early English they become larger, and in the Decorated are more important still, being lengthened as the triforium diminishes. In Perpendicular work the latter often disappears altogether, and in many later churches, as at Taunton, the clerestories are close ranges of windows.

Triforium.—The arcaded storey between the lower range of piers and arches and the clerestory. At Durham and Westminster it is called the "nunnery," and the tradition is that the

nuns sat there during the services, hidden by curtains, which is not at all improbable, since this is even now the case in some churches at Rome.

Presbytery.—That part in the chancel of the church set apart for the officiating priests.

Crypt (sometimes called the "Undercroft").—The vaulted apartment beneath a church, either entirely or partly under ground. Crypts owe their origin to the circumstance of the early Christians being compelled, for the sake of secrecy and concealment, to perform their sacred services in caves and subterranean places, some of which are still pointed out at Rome. Crypts are not unfrequent, especially under large churches. They seldom, however, extend the whole length of the church, being usually confined to the choir or chancel, and sometimes not extending so far as this. They are usually low and massive, of an earlier and plainer style than the superstructure.

Crypts were formerly used for service, and accordingly are occasionally covered with an arcade, and sometimes surmounted with a window to give light to the porch. In ancient times several religious ceremonies took place in the porch, especially those preliminary to baptism and matrimony. Having passed under the inner arch of the porch, we are now fairly in the church, and the first object to attract our attention is the *font*, which is placed near the principal entrance. The exact locality is not fixed, being sometimes in the central avenue of the nave, opposite the entrance, and at others under one of the arches of the aisle, near the porch, in which case it frequently adjoins one of the adjacent pillars. It is not unfrequently raised on a series of steps, which give it a more imposing appearance, and has always a space left around it for the accommodation of the priest, sponsors, etc.; for the former there is sometimes a kneeling-stone on the west side. Fonts in a perfect state are provided with covers, generally of wood, some flat and others of a pyramidal form, more or less enriched. We here speak of

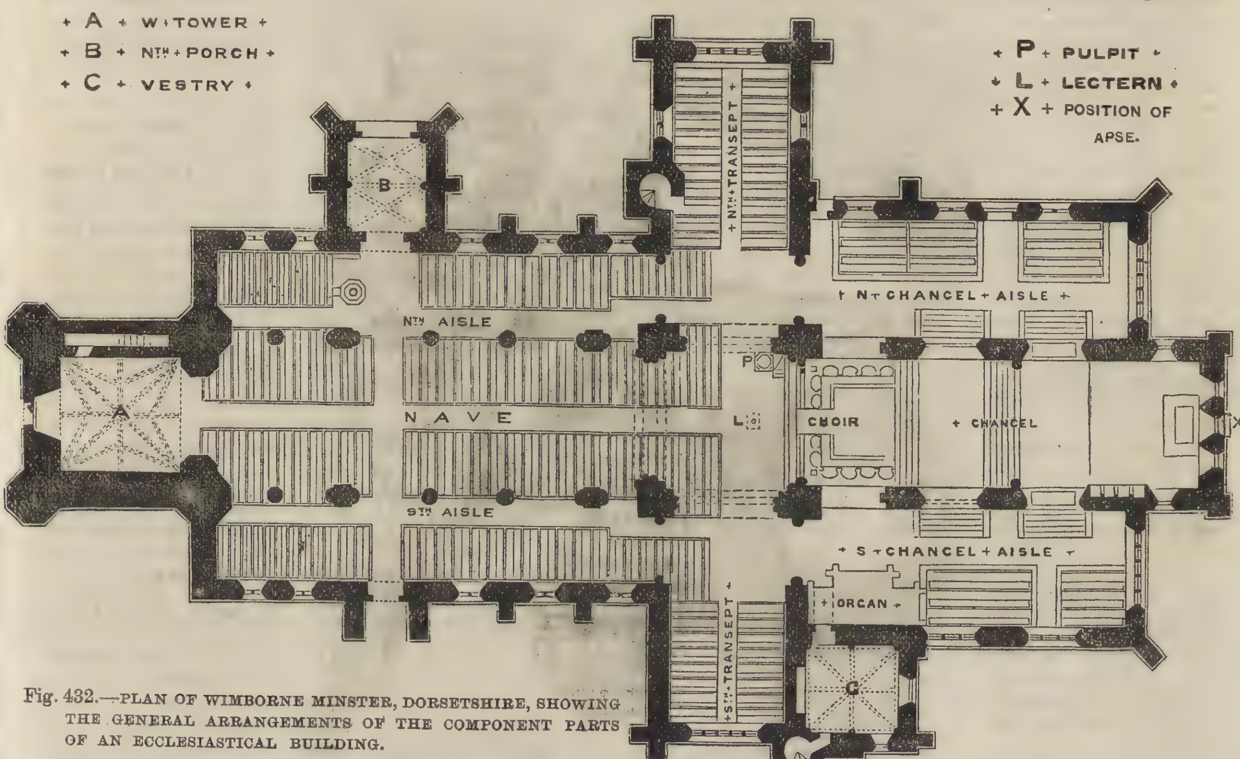


Fig. 432.—PLAN OF WIMBORNE MINSTER, DORSETSHIRE, SHOWING THE GENERAL ARRANGEMENTS OF THE COMPONENT PARTS OF AN ECCLESIASTICAL BUILDING.

provided with altars and other furniture requisite for the purpose. The most extensive building of this kind is that under Canterbury Cathedral, a portion of which is said to have been built by Lanfranc, in the time of William the Conqueror. The south-west corner of the crypt is called the French Church, which is still used for Divine service.

The following sketch of the internal arrangement of a church is quoted from Mr. Peter Nicholson:—

"On entering the church through the wicket at the entrance of the porch, we sometimes notice on the right-hand side of the door, often projecting from the wall, and partly covered by a niche, a stone basin, which is called a *stoup* or *aspersorium*, from its use, which was to contain the holy water with which, in olden times, the worshippers sprinkled or crossed themselves before entering into the body of the church. This was a very ancient practice, and was adopted in a somewhat different shape by the early Church; the small stoup, in fact, is a substitute for the fountain to be seen in front of the Constantinian churches, at which Christians were accustomed to wash before entering the sanctuary. The custom is typical of the purity of mind which should accompany our devotions.

"Before proceeding further, we may notice the stone seat or bench-table, which runs along the sides of the porch, and is fonts as they were in former times, not as they are now found in old churches; for the original ones are sometimes not only moved from their ancient positions, but even taken out of the church, and altogether discarded. On proceeding further into the church, the next object which probably strikes our eye is the *chancel*, and at its extremity the *altar*, with its appendages; but as this has been described in its proper place, we shall not stop to reconsider it here; and besides this, in fixing our attention on the more striking portion of the edifice, we have overlooked the pulpit. Few pulpits are to be met with of an earlier date than the fifteenth century; the oldest that remain are of stone, built up with the fabric, from which circumstance we may infer that they are coeval with the entire structure. There is a beautiful specimen at Beaulieu, Hants, which is attached to the wall, and entered by a staircase partly cut out of its thickness; another specimen is to be found in the Church of the Holy Trinity, Coventry, which is attached to one of the piers of the building. The later pulpits are of oak, usually of an octagonal form, having the sides panelled and enriched with carving, and the whole sometimes surmounted with a richly-groined canopy projecting over the head of the preacher. The position of the pulpit was probably always at the north-east or south-east end of the nave, near the arch which separates the nave and chancel."

SILK CULTURE.—I.

By Alexander Wallace, M.D.

VARIOUS WORMS PRODUCING SILK—CONDITIONS NECESSARY FOR SUCCESS IN SILK CULTURE—LIFE OF THE INSECT: THE EGG STAGE.

Silk, generally, is a material obtained from a sort of pod or purse, that remarkable envelope which many kinds of caterpillars make (especially in the family of the Bombyces), of more or less value and quantity, and which they weave around themselves preparatory to the change from the caterpillar into the chrysalis state. This pod when of a superior kind, and especially such as is obtained from domesticated worms, is distinctively termed a cocoon, and silk culture consists in the cultivation of those races which spin cocoons possessing a commercial value.

The following races of Bombyces produce cocoons which are more or less used in the production of silk-fibre:—

1. The *Bombyx mori*, or mulberry-worm—the only domesticated species; the silkworm of commerce, from which the great bulk of silk is obtained.

2. The *Bombyx Yama-Maï*, or Japanese oak-feeding silkworm, producing a greenish cocoon, from which a good thread may be reeled, highly valued by the Japanese for certain purposes—especially for embroidery, in which they are greatly skilled.

3. The *Bombyx Pernyi* of North China, an oak-feeder, producing a large greyish-brown cocoon, which has been reeled in China, but not yet in Europe.

4. The *Bombyx Cynthia*, feeding on the *Ailanthus glandulosa*, from China and Northern Asia; this also produces a long greyish cocoon, not reeled in Europe, but undoubtedly reeled in China, whence is obtained a peculiar silk, easily recognised by its extreme softness. Silk in piece goods made from these cocoons and from those of *Bombyx Pernyi*, is plentiful and cheap in the Chinese markets of the interior, and therefore may some day be fabricated in Europe.

5. The Tussur Moth (*Antheræa Paphia*) of India makes a large, very hard, dirty greyish cocoon; this is reeled by the natives to form the Tussur silk, well known in the Indian markets.

6. Allied to *Bombyx Cynthia* is the *Bombyx ricini* from Bengal, feeding on the castor-oil plant (*Ricinus communis*), producing a cocoon smaller, but very similar to that of *Bombyx Cynthia*.

7. Cocoons of other Bombyces, such as *Polyphemus*, an oak-feeder; *Cecropia*, a plum-feeder—both from North America; *Hesperus* from Cayenne, feeding on the *Cafe du Diable; Faidherbia Baubinicæ*, feeding on the *Cytisus cajanus; Bombyx fauvetyi*, from Uruguay, feeding on a species of *Mimosa; Pachypusa effusa*, also a *Mimosa*-feeder, from the Cape; *Attacus Atlas*, North India, feeding on the *Berberis Asiatica; Antheræa Roylei*, feeding on the evergreen oak of the Himalayas, etc. etc., have all been more or less the subject of experiment, but as yet none have been found sufficiently easy to reel; though doubtless most of these cocoons, if obtainable in large quantities at little cost, would be worth carding, and produce a useful, though perhaps not a very ornamental fabric.

The culture of the *Bombyx mori* is of very ancient origin. It is said that an empress of China, 3,000 years before the Christian era, was the first to unravel with delicate fingers the filmy thread from the cocoon, and dexterously to weave it into a beautiful web of cloth. The art was for a long while confined to the East, but about 550 A.D. two monks, having procured in India the precious eggs, concealed them in a hollow case, and hastened to Constantinople. Thence silk or sericulture spread in all directions, and is now a most important and staple industry in Central and Southern Europe, extending to a slight extent into Germany, Sweden, and even into Great Britain, where endeavours have from time to time been made with some success to cultivate the worm.

Fig. 1.—CATERPILLAR, COCOON, CHRYSALIS, MOTH, AND FOOD OF BOMBYX MORI.

Turkey, Egypt, Asia Minor, Persia, India, China, and Japan transmit large supplies of cocoons and of raw or reeled silk. Australia, the Cape of Good Hope, New Zealand, the Sandwich Islands, West Indies, and other of our colonies are waking up to a sense of the capabilities they possess of turning this very lucrative industry to advantage; while California, Russia, Chili, Turkestan, and other countries are commencing to draw large profits from sericulture. The conditions necessary for success in silk culture are—

1. To have a healthy, vigorous plantation of mulberry-trees. These generally thrive best on hilly sites, where the soil is light and gravelly; but they will grow almost anywhere, and in China have been seen planted like our willow pollards by the sides of streams. Several kinds of mulberry are used in silk culture. The *Morus nigra*, or common black, grows most luxuriantly at the Cape, but elsewhere it is generally rejected because of its slow growth; it does, however, very well for the early worms. The *M. alba*, or white mulberry, is the variety generally used in Europe; the rose-leaved variety being preferred in Italy, on account of its large, stout leaf. *M. Alpina* is suitable in some localities, as being a very hardy variety. A large-leaved kind, *M. Japonica*, recently introduced from Japan, is also much esteemed. *M. Moretti*, another Italian variety of high repute, and *M. multicaulis* from the Philippine Islands, possessing a thin, concave, but very large leaf, are also much grown. The latter being a very early kind, is used mainly for the young worms; its leaf is unfit for the elder worms, being thin and watery.

After a plantation is made, it should be left three years before any leaf is taken for feeding purposes, so as to give the trees time to get well established.

2. The next point of importance is the arrangement of the buildings or *magnaneries* in which the worms are "educated." These should be moderately lighted, and very well ventilated both by night and day. An even temperature, and a constant

current of pure air passing through without draughts, are of the utmost importance to the worms. The thermometer and hygrometer must be constantly watched, with a view to the maintenance of the proper temperature and dryness. Vermin, especially mice, must be excluded. In this country it will be well for the roof to face north and south, and for windows to look east and west, so as to obtain the greatest amount of sunshine. The interior should be so arranged that easy access may be had to the shelves on which the worms are placed to feed. Dandolo, the best authority, in his book, gives as the dimensions of a small laboratory, 40 feet by 18 feet by 12 feet high. This would contain a double tier of trays in the centre of the room, and a single tier round the sides; but as it is preferable to have a passage all round the trays for the sake of convenience, as well as for ventilation, it would be wiser to add 4 feet to the width, and also to the length, making it 46 feet by 22 feet, so as to hold two double rows of trays; or by adding another 6 feet in width and 2 in length, making the *magnanerie* 44 by 30 feet, ample room may be obtained for three double rows of trays with a passage on either side of them.

The unit, as it were, of measurement is the size of a sheet of stout double-glazed brown paper, viz., 45 × 29 inches, which is laid for the floor of each tray of worms. The inner measurement of each tray will be the same. Strong twine netting, of about 1 to 1½ inch mesh, is tightly strained across and fastened to the sides of each tray. It is a good plan to lace the nets tight with twine or strong thread to binding, fastened to the wood by means of tacks. A twine floor is far preferable to the boarded floors, which are much used in France, on account of its superior ventilation, preventing mould, which is very injurious to the worms. The trays may be about 16 to 18 inches apart vertically, the lowest about 6 inches from the ground, ascending as high as convenient, even to the top of the room, though in that case special means of ventilating the upper stratum of air must be devised, and a convenient ladder on castors be provided for moving round the room without noise, high enough to enable those in charge to attend to the worms on the higher tiers. Practically, six tiers vertically placed will be found as much as can be managed conveniently. The trays should all be of the same size, and the tiers should be level throughout the room. A table the same size or a little larger than the trays should stand in a convenient well-lighted spot in the centre of the room, where the trays of worms may be placed and carefully examined when necessary.

3. The third point of importance is the purity and sanity of the eggs to be operated upon. It is well known that a peculiar disease, "la pebrine," not yet thoroughly understood, has devastated many of the silk-growing districts, especially in Europe. It is therefore necessary to procure eggs or grain from countries as yet unaffected by the disease. With this view, large imports of eggs have come from Japan, China, and other parts, and the price of good grain has risen from 5s. to 25s. per ounce. In 1869 the total value of eggs imported into France alone for home use was as follows:—From Japan, 9,436,000 francs; Egypt, 1,232,000 francs; China, 560,000 francs. The total value of exports of eggs of French produce was 3,378,700 francs, being chiefly to Italy, the proportion of eggs required by Italy to those required by France being about 5 to 2. This shows the great demand for healthy seed from new countries. For the purpose of rearing sound grain, England is considered by French *savans* to be remarkably adapted by reason of its temperate climate. The Cape, California, New Zealand, and Australia are also especially favoured districts. In fact, the disease is eliminated and quite disappears under proper treatment in the latter country. Mr. Charles Brady, of Sydney, N.S.W., writes: "The mulberry of all varieties thrives here remarkably well; and I have every reason to believe that its silkworm may, even if severely diseased on introduction, some become quite sound by proper treatment under our invigorating atmosphere. My experiments have been uniformly successful, in regard to eliminating disease." I have myself received from Mr. Brady eggs of a celebrated European race (Milanaise), now very subject in Europe to disease, which have been pronounced, after microscopic examination by skilled experts, to be perfectly free from all sign

Fig. 2.—CATERPILLAR, COCOON, MOTH, AND FOOD OF BOMBYX CYNTHIA.

of disease. It is especially desirable to renovate the old races of the *Bombyx mori*—which have been ennobled in former generations for the quality of their produce, but which are now nearly exterminated from the prevalence of the disease—by importing their grain into new localities where disease is unknown. Settlers in Australia, New Zealand, and similar localities should especially consider what great pecuniary advantages are offered to them from this branch of sericulture. Another point of great importance, in reference to our Australian colonies, is mentioned by Mr. Brady. "I have had silkworms in all stages of their development, from the egg to the imago, every day in the year, and I am able to feed up several generations in the year, and rear a brood at will at any season. Hence we have a remarkable advantage in our climate, in being able to produce many crops a year, or, as it may be otherwise expressed, to spread the season over a large portion of the year, thereby gaining manifold what could otherwise be obtained." In Europe the annual worm having one brood only per annum produces the most valuable cocoon. The "bivoltine," or worm having two generations per annum, is also cultivated, but its produce is inferior. In hot countries, as India, silkworms having three or more generations in the year (such as *Bombyx Sinensis*, a monthly worm) are cultivated; the cocoon in these races, being always smaller, is deficient in quantity, and generally in quality of produce. The annual worm is therefore the most esteemed, and these races, according to Mr. Brady, may in Australia be made to produce three crops of silk per annum without deterioration of the cocoon. This gives a decided advantage to cultivators in that country.

The value of the different races of the *Bombyx mori*, admitting their sanity to be equal, depends on their produce, the cocoon—*i.e.*, on the amount of silk which can be reeled from a given number of cocoons, which should all possess more or less the typical points of the race: viz., the Novi, an Italian race, of which the Moricand is one of the best examples, spins a large, white, oval cocoon; the Milanaise, another very valuable race, spins a large cocoon, smaller than the Moricand, more elongated, of a buff colour; and so on. Japanese races are of different colours—white, buff, green, etc.—but all possess a peculiar property of being nipped-in in the centre, as if the cocoon had been spun in two halves and joined in the centre.

Cocoons which feel hard and firm to the touch possess more silk, and are preferred as having a greater value; thin and soft cocoons are rejected as inferior.

These three main points being secured—viz., a good supply of mulberry-leaves, a suitable *magnanerie*, and eggs of a healthy race of approved value—let us follow the life of the insect, beginning from the egg stage, to the cocoon; and examining the manipulation and treatment employed by *educateurs* in the different stages.

1. *The Egg Stage.*—The old proverb must be borne in mind: A good beginning makes a good ending. If deterioration takes place in the egg stage, vigorous healthy worms cannot be expected; therefore care must be taken even of the eggs. These are deposited by the moths on paper, cloth, or other suitable material. They should be kept in a cool airy room, free from damp, and once a month at least be thoroughly ventilated. The Japanese wrap the cards on which their eggs are laid in paper bags, and hang them to the roof of their dwellings, which, being made of bamboo, are very freely ventilated. During the egg stage alone, races may be transferred safely from one country to another, and the trade in silkworms' eggs has assumed large proportions. In 1869 two millions of cards, costing on an average 12s. 6d. each, were sent to Europe from Japan. Special steamers are chartered to bring home this valuable cargo as speedily as possible; and during the voyage, in suitable weather, the boxes are opened and the contents ventilated. In each box, which is three feet long, and on which a freight of £3 is paid, are packed 200 cards in separate grooves, so as to allow of ventilation between each card, and to avoid friction. Each card contains about five-sixths of an ounce of eggs, and costs from three to four dollars in Japan. It is a matter of the greatest importance to export eggs as soon as possible after they have been laid, and before they have been exposed to any chill from cold weather, especially if they have to travel long distances. Exposure to cold is necessary to set in action vital changes in the egg, which once begun cannot be stopped without deterioration; and a subsequent change to a warmer climate will then hatch out the egg prematurely. This I have proved for several years to be the case with the eggs of *Bombyx mori* and *Bombyx Yama-Maï*, and also with the cocoons of *Bombyx Pernyi*, *Cecropia*, and other races. The only safe rule is to forward eggs or cocoons in the autumn, as quickly as possible; ice in any form is dangerous, and should never be employed.

BUILDERS' QUANTITIES AND MEASUREMENTS.—III.

BY E. WYNDHAM TARN, M.A.

BRICKLAYING.

When the foundation of a building is formed of concrete, as described in the second lesson on "Building Construction," the length, width, and thickness of the concrete are entered under each other in the dimension book, and then cubed, being reduced to cubic yards in the abstract. If, however, the quantity is small, or the thickness less than twelve inches, enter the length and width only under each other in the book, and describe the thickness; it will then be brought into superficial yards in abstracting. State likewise the composition of the concrete, whether made with lime or cement, and in what proportions to the ballast and sand.

When concrete is employed as the material for building walls less than twelve inches thick, enter the height by the width, deducting openings, and bring it into superficial yards in abstracting, describing the thickness and mode of construction; if the walls are twelve inches and upwards in thickness, the cubical contents can be taken as before described.

Brick walls are usually measured by the foot superficial, the length and height being entered under one another in the dimension book, describing the number of bricks of 9 inches long which the wall has in its thickness—as half-brick, one brick, one and a-half brick, two bricks, and so forth. First enter the length of each course of footings separately, by the height of three inches, if there is a footing or set-off at each course, as in Fig. 1; or by a height of six inches, if there are two courses of bricks to any set-off, as shown by Fig. 2, and describe the number of

Fig. 1.

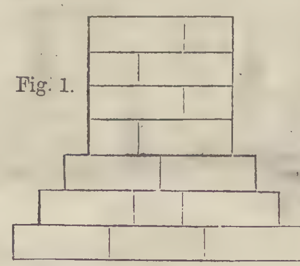
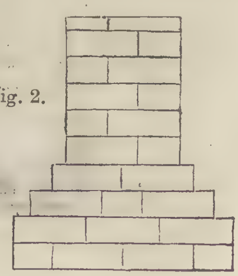


Fig. 2.



bricks in the thickness of the wall. Then enter the length of the walls by the height, as if solid, taking those of the same thickness together, and stating the thickness in bricks. Where several items of the same kind or thickness follow each other in the dimension book, write the word "add" against them, to save the trouble of repeating the description. Measure all projections of chimney-breasts, etc., in the same way, stating the amount of projection, whether half-brick, one brick, etc. The height and width of each opening are to be entered one under the other, putting the word "deduct," or "ddct." against the item, and stating the thickness of the wall in which it occurs. No deduction is to be made for sills of windows or stone dressings, flues, or for any woodwork bedded or built into the wall; but openings for fire-places are to be deducted.

To measure the length of the walls in a building which has square corners, take the external girt and deduct twice the thickness of any two of the walls, or else take the length of two walls on the outside, and of the other two on the inside. When the labour only is being measured, the external girt must be taken without deduction.

In abstracting brickwork, rule two columns for additions and two for deductions, writing "1 bk." and "1½ bk." at the head

of each; then enter all the measurements from the dimension book in one or other of these columns. Thus a wall $2\frac{1}{2}$ bricks thick will be abstracted twice, and entered under both columns. Add together all the deductions of the same sort, and also all the additions, take the former from the latter, and the quantity of 1 bk. walling and $1\frac{1}{2}$ bk. walling is thus obtained; the former being multiplied by 2 and divided by 3 is brought into $1\frac{1}{2}$ bk. walling, and can be added to the quantity already formed under that heading. The brickwork is now said to be "reduced" to the standard of $1\frac{1}{2}$ brick in thickness, and when divided by 272 is brought into rods.

When the thickness is three feet or more, the brickwork is often brought into cubic yards or feet.

Brick walls, which are measured in the above manner, are described in the bill according to the quality of bricks used in the backing up; and if superior bricks are used on one or both faces, the whole face is measured again, and described as "extra to malm (or other) facing." If a wall is built with a sloping or "battered" face, or is circular on plan, the face is measured separately from the solid walling, by the superficial foot.

Where old buildings have to be altered, and part of the walls taken down and rebuilt, the old materials being used up again, measure the walls by the rod "reduced" as above described, and enter them in the bill as so many rods and feet reduced, taking down, cleaning, and stacking old brickwork.

Fence walls are measured in the mode above described, but are usually kept separate in the bill if the joints are struck on one or both sides; but if pointed they may be taken with the other walls, and the pointing measured separately.

The building of ovens and setting coppers is measured by the foot cube, and the ash-holes deducted.

Underpinning old walls with new brickwork in cement is taken separately from the other work, and measured by the rod, as above described; unless the quantity is small, in which case it is usually charged in a day account, the time or labour and the materials being taken separately.

In measuring brick-nogged partitions take the height by the length, and bring it into superficial yards; deduct the area of all openings, but make no deduction for the timbers built in with the brickwork.

When a layer of asphalte, two courses of slates in cement, or any other kind of expedient is adopted for preventing the damp from rising in the walls, measure the length of the wall by the thickness, and bring it into superficial feet, describing the material employed.

Arches for cellars or vaults, and trimmer arches to carry the hearths of fire-places are measured by the superficial foot, taking the length by the girt upon the curve or soffit, and describing the thickness, and whether in mortar or cement.

Gauged arches, as described in Lesson IX. of "Building Construction," are measured on the face and soffit by the foot superficial; thus, in the flat arch shown at Fig. 63,* take the half sum of the lengths K L and F G, or the length between the skewbacks at half the height, by the depth A I; then take the length F G of the soffit by the width of the reveal, or distance from the face of the wall to the window-frame. In the curved arch of Fig. 65 take the girt of the curve half-way between E and D, from one skewback to the other, by the depth E D; then measure the soffit as before, the length by the width.

Pointing the joints of brickwork is measured by the superficial foot, taking the height of the wall by the width, and deducting openings, making proper allowance for pointing to reveals and soffits of openings. In bringing into bill the pointing is described either as flat-joint, tuck, or otherwise; and when old work has to be pointed the erection of scaffolding and raking out the joints must be added to the description.

Brick or tile paving is taken by the yard superficial, and described as brick-flat, brick-on-edge, in stocks, malms, clinkers, $\frac{1}{2}$-inch or 1-inch tiles, etc.; and the mode of laying is also stated, whether in sand, dry or grouted, on concrete, or otherwise.

Brick-on-edge coping to fence walls is measured in with the wall when in mortar; but if laid in cement, or if a different kind of brick is used, its length is taken separately, as well as being measured with the solid brickwork, and is entered as extra to brick-on-edge in cement.

* For this and Fig. 65, see TECHNICAL EDUCATOR, Vol. I., pp. 263, 264.

Measure all drains by the foot-run, describing the size and quality, and whether glazed-ware, socket-pipes, or built with bricks and tiles. Number all bends, junctions, traps, cesspools, etc., describing the sizes. Where large drains or sewers have to be measured they can be taken by the foot superficial, as described for arches, or the brickwork by the foot cube.

Measure by the foot-run all narrow cuttings to brickwork, such as chases, bird's-mouths, groins of arches, narrow splays, chamfers, beads, quirks, rounded corners, string courses, cornices, tile-creasing, filleting, cutting and pinning edges of landings, etc. But all splays and chases more than four inches wide are measured by the foot superficial.

Number all items which cannot be measured, as bedding and pointing sash and door frames, cutting and pinning ends of steps, inserting air-bricks, fixing chimney-pots, coring flues, setting stoves and chimney-pieces, etc.

Where iron hooping is used as a bond in brickwork its length is to be taken in yards, the width and thickness being described. Iron chimney bars are taken in the same manner.

FORTIFICATION.—VII.

BY AN OFFICER OF THE ROYAL ENGINEERS.

OBSTACLES.

General Remarks on their Application.—In every scheme of defence it is evident that a great effort must be made to render the enemy's advance as difficult and slow as possible.

The means employed for this purpose will, of course, depend upon the nature of the country, and on the sort of troops against which the war is being carried on. They may, however, be classified under two general heads.

1st. Those works (generally of destruction) which are intended simply to increase the difficulty, and cause delay in the enemy's march; but which are not necessarily within range of the points chosen for defence.

2nd. The appliances and arrangements usually available for the formation of obstacles which are not, perhaps, formidable in themselves, but yet answer their purpose in checking an enemy's advance, and forcing him to work at removing or destroying them while actually under the fire of the defenders.

When time admits of it there can be no doubt that the latter kinds of obstacles should invariably be employed to supplement the slight defensive powers of ordinary field-works, and, indeed, should be used in any part of a position where an offensive return or counter-attack on the part of the defenders is not intended.

The former class of obstacle includes every species of work that the inhabitants of an invaded territory can devise to hinder the advance of the invaders; and if thoroughly carried out, necessarily involves so considerable a loss of property that they should not be undertaken without carefully ascertaining that the results are likely to be commensurate with the cost.

There is no doubt that if a population is sternly determined to sacrifice and destroy everything, and utterly ruin themselves, rather than allow the invasion to succeed, they can in all countries greatly increase the difficulties of the enemy, and in some climates may render his success impossible. In 1812 the burning and destruction of everything that would shelter the enemy from the severities of the winter enabled the Russians to repel their otherwise invincible foes. It must be remembered, however, that in more populated countries it would be almost impossible to carry out such a means of defence as that referred to. The strong patriotic feeling of the people would probably prompt them to endeavour to obstruct, and hinder the march of the enemy's troops; but no really important results can be obtained unless the peasants are prepared to act in concert on some large and previously determined plan, and are, moreover, ready to follow up their acts by others much more difficult to execute, such as the total abandonment of the district by the whole able-bodied population. This would throw the labour of overcoming the obstacles on the invaders themselves, and would probably check the advance considerably.

What more usually happens, however, is that numbers of the inhabitants remain to look after their property, and consequently are seized and forced to supply the extra labour required to enable the enemy's advanced guards to clear the way for the

mass of their troops. Nothing, therefore, can be more senseless than for the inhabitants to fell the trees and block up the roads, if they remain on the spot, and have within a few hours to remove the obstacles they themselves created; unless from the enclosed nature of the country the enemy is necessarily restricted to these roads for his guns, wagons, etc., in which case every delay, however small, would be of use. Any action of this kind by the unarmed population, unless it is so carried out as to materially assist the cause of their own army, is to be deprecated, as it can only result in harsh treatment by the invaders, and (as was so often proved in the late war in France) rarely has the effect of making the heads of the enemy's columns halt or even check their advance. This was doubtless due in a great measure to the open nature of the country, which admitted of obstacles being easily turned or avoided, and also to the fact that in all modern armies the advanced guards are supplied with the means of bridging rivers, and clearing away such hindrances as are likely to be met with; moreover, they march so far in advance that any slight check or difficulties they have to encounter are probably overcome before the main force arrives. In many parts of England the fences are so numerous and large that an enemy would be obliged to keep to the roads with his guns and cavalry, and in these places the passive obstructions that could be so readily made by ordinary farm labourers, such as felled timber, barricades of carts, etc., would be invaluable, provided they were carried out intelligently under the direction of engineer or staff officers, who, realising that the enemy will advance by many roads at once, would take care that labour was not wasted on obstructions that could be easily avoided.

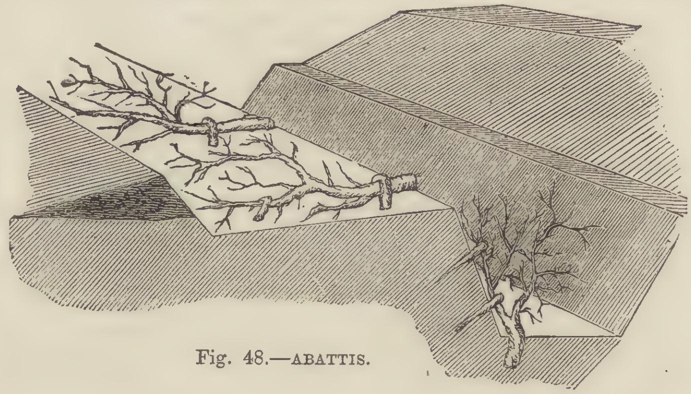


Fig. 48.—ABATTIS.

The most important of this class of obstacles are the destruction of railway tunnels, bridges, dykes, canal banks, etc. Their destruction, however, is often a severe national loss, which is felt long after the war is at an end, and therefore the instinct to destroy everything that may be of use to the enemy should not be blindly indulged in. There are, of course, cases when the safety of a retreating army, and possibly the fate of a nation, may depend on the timely destruction of some great bridge or other public work, by which the delay of even a few hours is occasioned. It should be recollected, however, that if the work of bridging is unopposed, a military bridge can usually be thrown across any ordinary river in about three-quarters of an hour, and that consequently the destruction of a great national work may really only result in delaying the enemy's march by that length of time. When a railway viaduct is destroyed under these circumstances the inconvenience to the enemy will be far more serious, as a temporary wooden bridge to bear railway traffic must needs be a large undertaking, especially if care has been taken in the demolition of the piers to leave no solid basis remaining from which to support the new bridge.

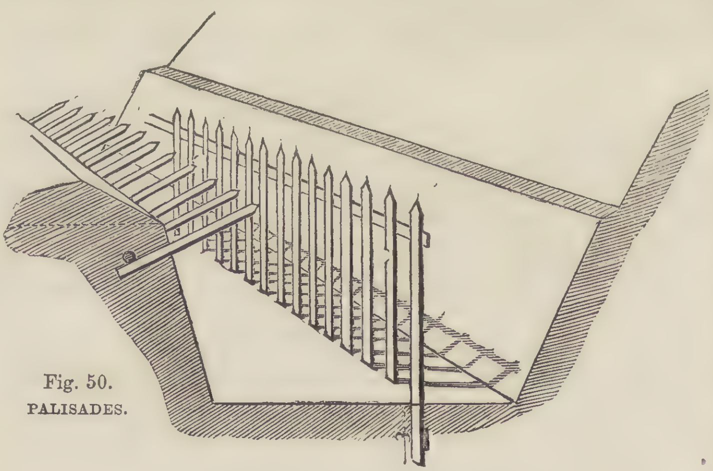


Fig. 50.
PALISADES.

Obstruction to Railways, etc.—In selecting a railway tunnel for demolition, one should be chosen at some point on a main line where, from the nature of the country, it will be a work of great difficulty to divert the railway and carry it round or over the range of hills through which the tunnel is bored. A case of this kind, that gave much trouble to the German troops, was a tunnel on the Paris and Strasburg line, about thirty miles east of Paris, which was found so difficult to repair that a loop line had to be constructed to avoid it. Railways may be temporarily obstructed in time of war by small parties of men, who should collect the rails and sleepers, and having formed a fire with the latter, the rails should be heated until they are capable of being bent and twisted, so as to prevent their being used again. The destruction of the water-tanks, turn-tables, and other accessories of a railway-station, could be readily and rapidly executed by men accustomed to their uses. The question of the repair and demolition of railway lines in time of war is, however, too large a subject to be dealt with here.

An army retiring through an enemy's country would probably resort to the use of this more serious class of obstacles, both because it would be reckless of the damage done to the national property of their adversaries, and also because any of the slighter kind of obstacles would be promptly removed by the population to facilitate the advance of their own troops; whereas, exactly the reverse of this policy would be adopted as soon as the retreat had to be conducted through its own territory.

Inundations.—Small streams, rivers, etc., may be converted into a most valuable passive defence by forming embankments or dams across the valleys of such a height as to cause the water to rise and inundate a considerable extent of country. An inundation is only really a serious obstacle when it is not fordable, *i.e.* where the water at its shallowest part is at least six feet deep. This, however, is not often practicable, as it would in most cases involve the construction of dams too large and too solid to be hastily built. A shallow inundation may, however, be rendered very difficult to cross, by digging deep trenches, pits, etc., at intervals across the probable line of the enemy's advance, and causing the water to rise just so high as to hide these from view.

The length of valley inundated will depend upon the height of the dams and on the slope of the water-course of the valley itself; the breadth of the inundation on the height and length of the dam and the slopes of the sides of the valley.

A contoured survey or levels must have been taken before the exact size of the dams and extent of inundation can be determined; and as the inundation is only an obstacle so long as the dams are in good order, it follows that their position should be such that they can be seen and defended by the fire of troops placed on the near side of them.

As regards the materials to be employed, no data can be given, except that the side of the embankment that has to retain

the water must be faced with clay well puddled or mixed, and that the thickness of the bank at top, if constructed of earth, should at least be equal to the depth of water, the slopes being on the side next the water $\frac{1}{3}$, and $\frac{1}{1}$ on the other side (Fig. 47).

As in the course of time the water would gradually rise and flow over the embankment, and would thereby certainly destroy it, sluice-gates are a necessity for every dam, in order that the level and action of the water may be controlled.

Of the class of obstacles used to delay the enemy while under fire, the following are those most generally employed:—Abattis, entanglements, pointed stakes, trous de loup, palisades, fraises, fougasses, chevaux de frises, crow's feet.

In their application the following principles should be borne in mind—viz., that they should be so placed as to be hidden from the enemy's fire, while within view and range of your own works; they should be so solidly constructed as to cause a serious check to the attacking troops, and should give no cover to them when they are engaged in breaking through the obstruction.

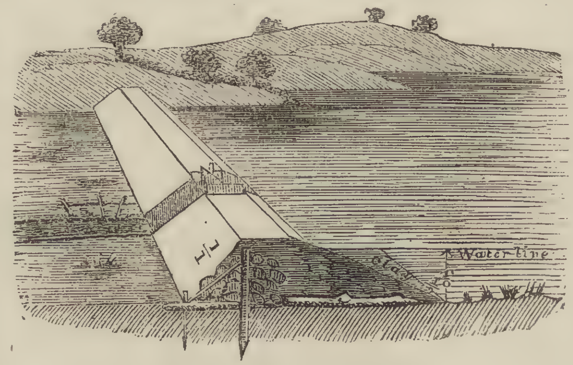


Fig. 47.—AN EMBANKMENT.

Abattis.—Abattis consists of a number of trees or large branches placed in a row on the ground, with the boughs (which

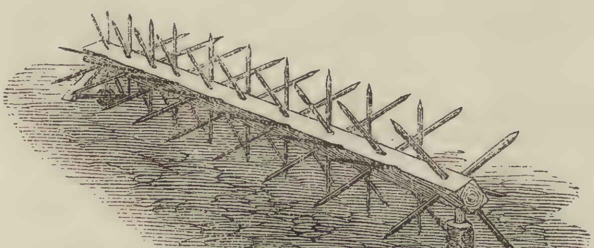


Fig. 52.
CHEVAUX DE FRISE.

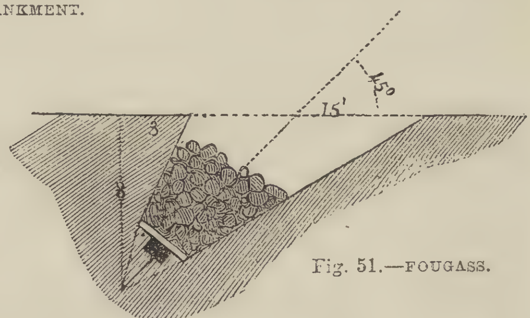


Fig. 51.—FOUGASS.

are pointed) directed towards the enemy. Where the trees are growing on the spot required for the abattis, an admirable obstacle can be readily made, as the trunks should be only sufficiently cut through to allow of the trees falling over. By this means it will be very difficult for the enemy to remove them, or get through while under fire, as each large tree would be a fixture, and smaller branches should be interlaced with their own, to complete the obstacle. The real difficulty in the employment of abattis is the removal of large trees and branches, from where they are cut down, to the required points. The mode of attacking abattis would be to break a number of large gaps in the line with shells, before the attacking columns came up; and for this reason, when used in the defence of field-works, abattis should be placed either upright in the ditch at the foot of the counterscarp, or else in front of the ditch, but protected from view of the enemy by a raised glacis (Fig. 48).

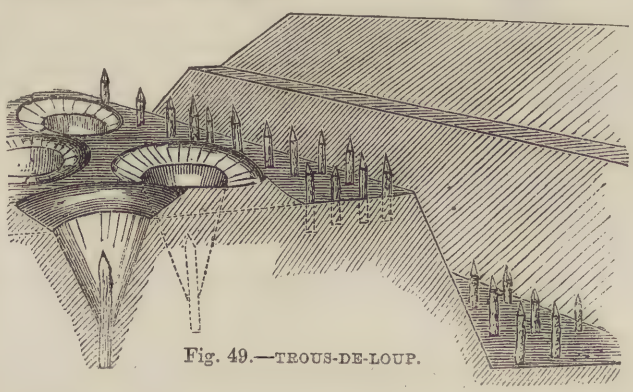


Fig. 49.—TROUS-DE-LOUP.

Entanglements.—An entanglement is in many instances a useful obstacle, and requires no great skill to construct. It may easily be made by driving a number of rows of stout pickets in front of a work, and connecting them together with strong wire, at about two feet from the ground, so as to prevent the possibility of a rush forward on the part of the attacking columns, until the wires have been cut. This would be a troublesome operation under fire, and one which is not satisfactorily performed by the action of shells, the effect of which is often to twist and bend the wire, forming a more difficult entanglement than before. Thick brushwood and coppice may be formed into an entanglement by cutting the stems half through, and bending them down, the ends being buried or pegged to the ground. A series of rough hoops are thus formed, which are difficult to get over by a body of men moving rapidly forward, and who are, moreover, under fire while so doing.

Pointed Stakes.—Rows of stout pickets driven about three feet into the ground, and their ends subsequently pointed, may be employed with advantage to increase the difficulty of attacking a work. If placed in the bottom of a ditch, and near the edge of the counterscarp, they render the task of jumping into the ditch a dangerous one. This class of obstacle was freely used by the Chinese, in the defence of the works the British troops attacked on the Peiho river.

Trous de Loup.—Trous de loup are pits arranged in several rows, and placed chequerwise, so that the interval between each pair is covered by the pit in front. Each pit is furnished with a stout pointed picket, driven into the bottom of the pit. They should either be of such a depth, and so narrow at the bottom, that they cannot be used as rifle-pits by the assailants, or so shallow as to afford no cover. The larger kind are usually conical in shape, ten feet from centre to centre, and six feet deep (Fig. 49).

Palisades.—Palisades are stout palings, the uprights of which are usually half timbers nailed to a couple of longitudinal rails. The uprights should be placed so close, as to render it difficult to get through even by the removal of one of them; and of such a length, that they project ten feet above ground, their butt-ends being buried three feet below the surface. Palisades, therefore, are somewhat like stockades in construction, but, of course, do not give protection from fire, and are used merely as an obstacle, placed usually either in the ditch, or across the gorge of an open work, in which positions they would be screened from view, and possibly from the fire of the enemy. When placed in the ditch, they should be either in the centre, or somewhat nearer the counterscarp side, to be as much protected as possible, and yet not so near that they can be jumped over from the edge of the glacis (Fig. 50).

Fraises.—Fraises are palings similar in construction to palisades, but placed in a nearly horizontal position on the berme, or projecting from the counterscarp of a work, to increase the

difficulty of the passage of the ditch. In order that the ribband, or top rail, should not be used as a means of pulling them over bodily into the ditch, it is nailed nearer the butt-end, and is covered by the earth of the parapet or glacis. Fraises on the escarp side are liable to damage by the enemy's fire. Both fraises and palisades are sometimes constructed of wrought iron, and used in connection with permanent fortifications.

Fougasses.—Fougasses are small mines placed close to the surface, and loaded with stones or shells. They are intended to act as a species of mortar, propelling their contents in the direction and at the moment of the attack. In some situations, such as the end of a street in a village where the exact point of attack is known, they may be useful as a means of defence; but, except for their moral effect, it is doubtful if they actually produce many casualties, and, moreover, they can only be used once, and cease to be an obstacle after being fired (Fig. 51).

Chevaux de Frises.—Chevaux de frises are made by fixing a number of spikes, of iron or wood, to a large beam of wood, which is supported at either end. These spikes project in every direction, and are available for closing the opening into a work, or preventing troops from advancing up a street (Fig. 52).

Crow's Feet.—Crow's feet are formed by welding together four iron spikes, about 4 inches long, in such a way, that in whatever position it may be placed, three prongs are on the ground and the fourth upright. They are useful as a means of maiming horses and stopping a cavalry charge. They may also be employed to prevent a ford being used, provided the bed of the stream is hard enough to prevent their being sunk in the mud.

PAPER AND CARDBOARD MAKING.—II.

BY GEORGE TINDALL.

PREPARATION OF MATERIALS.

MATERIALS of all kinds, whether rags, waste, or vegetable substances, require in the first place careful sorting, to free them from impurities, before being used for any but the very coarsest descriptions of paper. This operation is usually performed by women and girls upon a lettice or table, the top of which is formed of an open-meshed wire netting, through which the dust and finer dirt fall, as the materials are turned over; a common knife, generally a piece of the blade of a scythe, is fixed on one side of the table, or at each end if two girls work at one table, for the purpose of opening seams and cutting rags into smaller pieces. If fine or superfine rags are being sorted, they are generally cut ready for boiling during this operation into pieces not more than four inches square, and this is called cutting by hand; but common rags are usually cut by machinery, and when sorted only large pieces of rag are cut. Here all woollens, braid, etc., are carefully cut off, pins, buttons, and other foreign substances are removed, and the rags are dropped into a box in front of the lettice, which is usually divided by partitions so that the qualities of rags may be kept separate. The degree to which this sorting is carried, depends entirely upon the kind of paper for which they are to be used: if for fine writings, the white rags are carefully sorted out, and the cottons separated from the linens; whilst for inferior printings, etc., the rags are all thrown into one box, only the rejected substances being separated. Waste, both cotton and linen, is very variable in quality, some being very clean, and requiring but little sorting, whilst others are often full of impurities of various kinds: splinters of wood, bits of leather, metal, and many other things, prevail in different samples, depending in a great measure on the different processes of manufacture in which the waste is produced; many kinds are full of impurities, so fine that it is useless attempting to get rid of them by sorting, and such substances are separated by a process called "willowing."

Esparto also is usually first sorted on lettices, and the coarse root and other impurities removed: this grass when pulled—for it is not cut—is tied up in small bundles, and these again are tied up with esparto ropes into large bundles or pressed into bales, and secured with hoops or wire, and large stones are often found carefully concealed in the centre of the small bundles. The roots are not used in the manufacture of white papers, but are available for rough browns or for wrappers.

After sorting, rags requiring further cutting are taken to the "chopper," a machine, in its most improved form, consisting of a large revolving disc, on which strong steel knives are fixed, working against a stationary one. The rags are fed into the machine by means of a felt or blanket passing between two rollers, which compress the rags, and deliver them to the fixed knife, when they are cut to pieces by the action of the revolving blades, and thrown out at the back of the machine.

Waste and other substances requiring it are then willowed by passing through the machine of that name, or, as it is more commonly called in the woollen manufacture, the "devil," being used for tearing up old woollen materials into mungo for remanufacture. This consists of a conical cylinder set with teeth about one inch square, and projecting about three inches from the cone. This cylinder is made to revolve at a very rapid rate, usually about 150 revolutions per minute, the teeth on the cylinder working between similar teeth firmly fixed on the outer casing of the machine. The rags or waste are fed in at the small end of the cone, and are torn to pieces between the teeth of the machine as they pass to the wider end, where they are violently expelled in the current produced by the rapid revolution of the cone. By this means the fibres of the rags or waste operated on are loosened or opened, so that the dirt is more easily acted on, and any lumps or knots are at once expelled.

The next operation is that of dusting, which is performed in a strong open meshed wire cage of considerable length. This is made to revolve slowly, and is enclosed in a wooden framework to keep in the dust expelled from the rags. This cage is either made wider at one end than the other, or the centre is fixed lower at one end, so that there is a gradual fall sufficient to send the rags forward, and the dirt, already loosened by the cutting and willowing processes, passes through the interstices of the wires, the rags being thrown from side to side by the revolving motion of the cage, as they traverse it from the upper to the lower end, where they fall out and are removed to the boilers.

Straw is prepared for boiling by cutting it into chaff, and, unless used for fine papers, needs no sorting. Wood is acted on either by reducing it to powder by grinding, or by breaking and crushing it. Several mills have already adopted, or are about to adopt, the latter plan, in which, by means of a powerful "chopper," a knife secured to a heavy cast-iron disc revolving at a high speed, the blocks of wood are cut into slices half an inch thick, and these are afterwards crushed between iron rollers, and turned out in small chips ready for the boiler.

The boiling process is one of the most important in the manufacture of paper, especially from crude vegetable fibres, as unless these are thoroughly reduced, and all the various parts softened, so as to easily crush and break up, it is impossible to bleach them thoroughly or convert them into fine paper. Fine rags are easily treated: it is only necessary to boil them a few hours in a solution of caustic lime, or with the addition of a small quantity of soda ash, in any kind of pan open or closed, and they are ready for the washing engines; but for other substances stronger solutions must be used, and pans specially adapted for the purpose. Two kinds of boilers find most favour in this country, fixed kiers with a vomiting-pipe, and cylindrical or spherical boilers, which are kept slowly revolving during the boiling of the materials. The former is usually an upright cylindrical boiler with a man-hole at the top for feeding in, and also one near the bottom to take away the boiled materials, or the pan may be shallower and open at the top if no pressure is required; in the centre is an open pipe into which the liquor is freely admitted, and a jet of steam from a steam-pipe opening into this, forces the boiling liquor with great violence up the pipe, over which is placed an iron umbrella, which distributes it over the whole of the pan, thus keeping the boiling mass in a state of constant agitation, and bringing every portion of the contents of the pan under the action of the caustic liquor. The kier is usually made slightly spherical at the bottom, and, if used under pressure, at the top also; it is furnished with a false bottom of perforated plates, through which the sand and other impurities left in the materials escape during the boiling process. The revolving boiler is generally cylindrical, but a spherical one has been introduced; it is mounted on strong metal standards, and made to revolve slowly, a steam-pipe being introduced into one axis for the purpose of boiling. Only one man-hole is required, as the boiler can be filled while this is at the top, and emptied when it is at the bottom into a box placed underneath it. The motion of the boiler, as it slowly revolves, continually throws the contents from side to side, and this is generally assisted by plates running across the length of the boiler, and placed at an

angle to the sides, so that every portion of the materials is equally acted on during boiling.

Esparto, straw, and wood require boiling for several hours in a strong solution of caustic soda, the two last-named substances under very considerable pressure; in some mills, where rags and waste are also used, the liquor, after use for any of these substances, is pumped into a cistern, and used over again with the addition of a little caustic lime for the boiling of rags. Caustic soda may be procured already prepared and solidified in drums of iron, and when used in this state the drums are cut open and the contents simply added to the material to be boiled, with the addition of a sufficient quantity of water; but most makers prefer using soda ash, and making it caustic before using; this is done in round open pans fitted with an agitator inside, turned by steam or by hand. The soda ash being placed in the pan with water, and heated by means of a jet of steam, sufficient caustic or hydrated lime is placed in a cage inside the pan, and the agitator is set in motion; a strong ebullition is immediately set up, and the lime loses its caustic qualities, which are transferred to the alkali, rendering it a much stronger and more active detergent. After agitating the liquor for some time, it is allowed to stand, and the clear liquor is then run off into a cistern, the impurities settling to the bottom of the pan, and the refuse lime being retained in the cage in which it was placed; the pan is again filled with water, which is also agitated for some time, and after standing is again run off into the cistern, and added to the strong liquor. This may be repeated two or three times with advantage, taking care that the liquor used is of known strength at the time.

The process of boiling is simple. If rags are used, as they are brought from the duster they are fed into the boiler, usually a revolver; the requisite solution of caustic lime or soda, and spent esparto liquor, if used, is added; the man-hole is screwed down, steam is turned into the boiler, which is at the same time set in motion; and after boiling four to six hours, they are emptied into trucks, and sent to be washed. Stronger materials, such as hemp and jute, require a stronger solution; but all those materials described in our first paper as Class *a*, having previously undergone some preparation of this kind, are much more easily and cheaply boiled than the second class. This process is necessary to destroy greasy matter, and to loosen the dirt among the fibres of the material, a great portion of which is carried off during boiling. Esparto is usually boiled in the fixed kier, but sometimes in the revolver, and for this substance a large proportion—in fact, over 20 per cent.—of caustic alkali of ordinary commercial strength, say 48 per cent., must be used, and the boiling continued for eight hours or more before this substance is sufficiently digested: when properly boiled a large handful should be easily twisted to pieces, whilst before boiling three or four blades of this strong grass together defy the efforts of the strongest man to break them. Straw is still more difficult to boil well, on account of the knots which occur so often in the stem: this substance, therefore, is boiled in strong steam boilers under considerable pressure, and sometimes these boilers are fixed in brickwork, and agitators are kept in motion inside to mix up the boiling mass, and prevent any portion of the contents from becoming burnt against the sides of the hot boiler. Wood is also very refractory, and requires a special boiler and very high pressure to reduce it to such a state as to allow of its delicate fibres being got out unbroken. The particles of wood broken up as before described are put into cages, and the boiler filled with these cages: by this means the wood is kept always covered by the boiling liquor, and prevented from floating at the top and becoming charred; after being sufficiently boiled the pieces of wood are so much softened that they may be crushed up between the finger and thumb like so much tinder.

After the materials have been boiled a sufficient length of time, the liquor, if a strong one has been used, is run off, and either pumped into a cistern to be used for rags or for evaporation, or allowed to run to waste, and if possible a copious stream of water is allowed to run through the materials, especially esparto or straw, for the purpose of washing away the gummy and resinous matters which adhere to crude fibres after boiling. The materials are then thrown into wood and iron boxes on wheels, and sent down to the washing engines.

Waste papers, after being dusted in the usual way, are boiled in strong caustic soda in a washing or poaching engine, such as will be described in our next paper, covered with a lid, and with a rolling motion, so that during this process the papers are broken up and partly reduced to pulp, whilst the ink is discharged, and carried away at the same time. This class of waste can, however, only be used for a very inferior class of printings. Clean paper cuttings are best boiled in water only, in an open pan, and stirred with a rod until they are thoroughly softened; they may then be used with other materials for the finer papers.

In boiling at low pressures the exhausted steam from the various engines in the mill is generally used, and this is often collected into a single pipe and conveyed to the boilers. This method may be economical where engines sufficiently powerful are employed; but it must be remembered that this back pressure has to be overcome by each engine in addition to its own work, and other more important processes may be impeded by this extra strain put upon their driving power.

From what has been said above it will be seen that the boiling of vegetable fibres is by far more costly than that of rags and waste. For the latter materials a small quantity of lime at 13s. a ton suffices; while for the former a considerable quantity of soda ash, worth £8 a ton, is required; and it must be remembered also that the waste of crude fibres under this treatment is at least twice as much as that of rags, etc. After this stage, the working of both classes of materials is nearly the same, so that it is here the comparative values of materials to the paper-maker must be tested, in order to decide what is best to be used for a given paper. So long as esparto could be bought at £5 to £6 a ton, it competed favourably with rags at £13 a ton; but when, as was the case a very short time since, esparto advanced to £10 a ton, and the same class of rags to £16 a ton, then their relative values changed considerably, and an enormous impetus was given to the use of straw and wood.

The great cost of soda ash used in this process, added to the pressure brought to bear by landowners on streams, where the deleterious effects of the spent esparto liquor in destroying the fish were severely felt, has induced many paper-makers to recover the soda ash after use by evaporating the liquor, and calcining the residue; and as this can be done with great saving to the maker, it will doubtless become the general practice. The liquor, as it leaves the boiling pans, is pumped up into tanks, and there evaporated, until it becomes of the consistency of treacle; it is then passed into a series of shallow tanks built in brickwork, which with flues passing between them constitute a furnace, heated by means of a coal fire at the bottom: as the liquor becomes thicker it is pushed down into a tank at a lower level, and so on, gradually losing its water, until in the bottom pan it becomes almost solid, and is then pushed forward into the fire and burnt, assisting by its own heat in the evaporation of the remaining liquor; the ashes are then carried away and thrown in a heap, and this is left for some days to burn itself out, soda ash of a comparatively pure character being the result, except in the outer portion of the heap, which has been subjected to the action of the atmosphere and is blackened; this is removed and thrown away.

The restrictions imposed by the Pollution of Streams Act have prevented many makers, especially in the south of England, from using crude fibres, in consequence of the poisonous effects of the spent alkali; whilst in Lancashire and the north of England, where the streams are already fouled by other manufacturing operations, these fibres are extensively used, and paper-making in this part of the country has thereby received such an impetus as renders it likely to soon eclipse the county of Kent, the cradle of paper-making, and its southern neighbours, if it does not already do so. This only at present applies to the quantity of paper made, not to the quality.

THE LATHE.—III.

By Henry Northcott.

MODIFICATIONS OF THE LATHE FOR SPECIAL PURPOSES—BACK GEARING FOR CUTTING METAL.

The ground we have traversed has thus far been common to all classes of turning, but from this point improvements in the lathe have divided themselves into several main classes, depending upon the style of work the lathe has been designed more especially to perform. Thus the mechanical engineer has increased the power of the lathe, so as to enable work of considerable magnitude to be turned as easily as the smallest wire in the simple

lathe; he has adapted mechanism so that the lathe may be driven by the powerful force of steam; he has increased its accuracy by rendering accuracy no longer entirely dependent upon the operator's skill; he has gradually added to it mechanism by which the action of the lathe is rendered automatic; and he has rendered it capable of producing not only circular work, but such irregularly-shaped articles as gun-stocks, shoe-lasts, and others; and he has adapted it to a multitude of uses, suggested to him by the great variety of forms he is continually called upon to produce.

The amateur mechanic also, whilst using to some extent the means devised by the engineer for obtaining power, accuracy, and the power of self-moving, has contrived to increase the powers of the lathe by the addition of mechanism for planing, for cutting the teeth of wheels, for drilling holes, and various other operations, each of which usually requires a separate machine, but which on a small scale are quite readily and satisfactorily managed in the lathe.

The ornamental turner, on his part, has in another direction added immensely to the powers, and also to the complexity, of the lathe. He has added various instruments called chucks, some to vary the position of his work, some to produce non-circular sections, and others to produce all kinds of beautiful curves and ornamental figures, some of which are singularly graceful, and some far too intricate for the eye to follow unassisted by the microscope. The ornamental turner has also added means for the exact division and arrangement of his work, various cutting instruments for the production of ornamental solids and carved work, apparatus for cutting medallions, and various other mechanism. All these improvements and additions have made the lathe certainly one of the most useful machines known to man, and it would be as easy and as short a task to enumerate what cannot be done in the lathe as to say what can. And so far from its work being necessarily of a circular section, I have succeeded in producing by *continuous rotation*, in the same way as for a cylinder, and of any required length, articles whose sections are perfectly square.

The space at my disposal is too limited to allow of my describing the whole of the various modifications of the lathe; but I shall endeavour, by describing a few of the most important and most characteristic, to convey some notion of its extended usefulness.

Fig. 10.

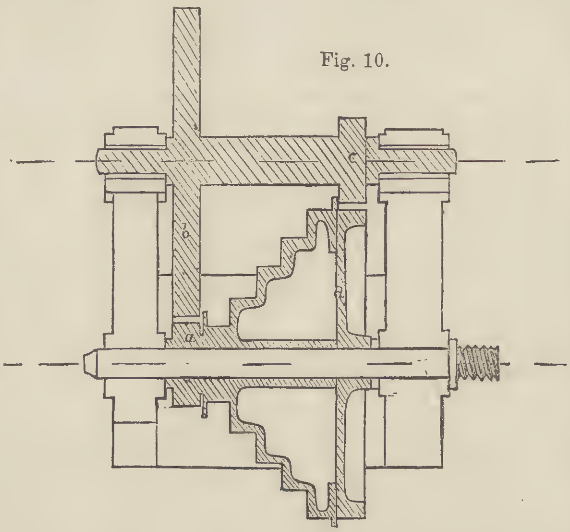
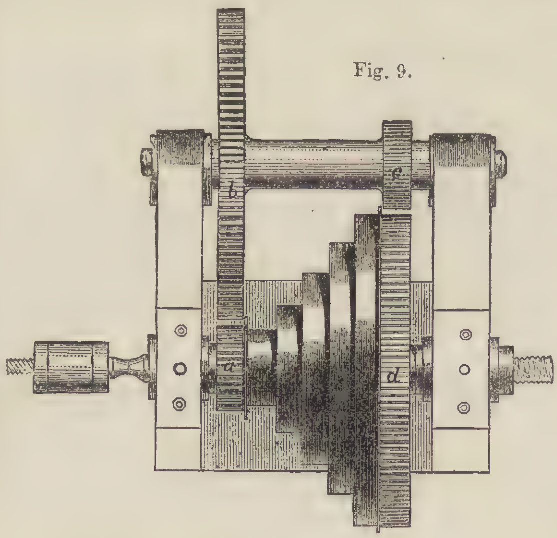


Fig. 9.



The greater power is obtained for cutting large pieces of metal by the addition to the lathe of the back gearing shown in Fig. 9. This gearing consists of two pairs of spur-wheels and pinions; one pinion, *a*, being attached to the usual lathe-pulley; a wheel, *b*, and pinion, *c*, being fastened upon a short shaft or axis placed behind the lathe-spindle; whilst the remaining wheel, *d*, is keyed upon the lathe-spindle. In this arrangement of gearing, the pulley is not keyed directly upon the lathe-spindle, but may rotate freely upon it, without drawing round the spindle; or it may be made to rotate the spindle also by connecting it to the wheel *d*. The shaft carrying the wheel and pinion may be drawn towards the lathe-spindle, so as to cause the teeth of the several wheels to gear or engage with each other; or the shaft may be removed outwards until the wheel-teeth become disengaged and capable of independent rotation. When ordinary light turning is being practised, the shaft carrying the back wheel and pinion is withdrawn, so that these wheels then remain idle, and the pulley being connected to the wheel *d*, by means of a small sliding bolt and nut at the side, the lathe-spindle is rotated in the ordinary manner, and at the ordinary speed. But when heavier work has to be performed, and greater power is required, the back shaft is brought in until the several wheels gear with each other, and the lathe-pulley is detached from the wheel *d*, to allow of its being rotated independently of the lathe-spindle. Now, on the lathe being set in motion and the lathe-pulley rotated, the pinion *a*, attached to the pulley, drives the wheel *b*, the back shaft or axle, and the pinion *c*, which latter in its turn gives motion to the wheel *d*, attached to the lathe-spindle, and so to the lathe-spindle itself, and any work attached to it.

The sectional illustration of this double gearing we have given in Fig. 10, in which the same letters are used, will best enable the reader to understand the arrangement and its mode of working; but it must be clearly understood that, whilst the large wheel *d* is always keyed fast upon the lathe-spindle, the pulley and pinion *a* may be connected to or disconnected from the lathe-spindle at pleasure. Disconnected from the spindle when the double gearing is in use, the pulley runs freely upon the spindle, driving the latter not direct, but through the other wheels at a much slower speed. For example, supposing the pulley to be rotated, say, 900 times per minute, the pinion *a* to have 20 teeth, the wheel *b* to have 60 teeth, the pinion *c* 20 teeth, and the wheel *d* 60 teeth, if the pulley were connected to the wheel *d*, the latter and the lathe-spindle would necessarily rotate the same number of times as the lathe-pulley itself, or 900 times per minute; but with the double gearing in action, the pulley and pinion *a* would drive the wheel *b* at a speed the inverse ratio of the sizes of the wheels, or 60 : 900 : : 20 : 300, and the speed of the wheel *d* and the lathe-spindle would be 600 : 300 : : 20 : 100. The pulley therefore, in rotating 900 times, would drive the back axis around 300 times, and the lathe-spindle 100 times; and, disregarding friction, whilst the speed of the lathe has been *decreased* nine times, its power of overcoming resistance has been *increased* to precisely the same extent. Or in other words, by the use of this gearing we can take a cut nine times as heavy, or one that opposes nine times the resistance to the lathe's rotation. The value of this addition to the lathe is now very apparent, but besides the increase in power, the decrease of speed is very frequently desirable of itself, as all materials can best be turned when rotating at a certain speed; and even with wood, when this speed is very much exceeded, the tools are spoiled by the excessive heat that is developed by the friction.

TECHNICAL DRAWING.—L.

GOTHIC STONEWORK.

GOTHIC ARCHES.

THE principles of the general construction of arches having been given in the series of papers which have already appeared on "Building Construction," it will only here be necessary to describe the characteristic forms of those associated with that period of architecture which forms the subject of our present study.

It has been said that the semi-circular arch (Fig. 433) is characteristic of the Norman period. Although, however, it is certain that generally the Norman arches were of this form, it is equally certain that they were not so universally. A form is frequently found in which the spring of the arch does not take place from the *abacus* or upper member of the capital, but at some distance above it. An arch of this kind is said to be stilted (Fig. 434).

There can be no doubt that this form of arch was not so much a matter of taste as of necessity. It is evident that the arches were stilted to admit of constructing the vaulted roof according to the simple method then known; one essential feature of which required the four arches of the vault to be of the same height. Stilted arches sometimes approach the *horseshoe* form (Fig. 435), in which the centre is above the springing. It is probable, however, that this form is seldom intentional, but the result of imperfect construction.

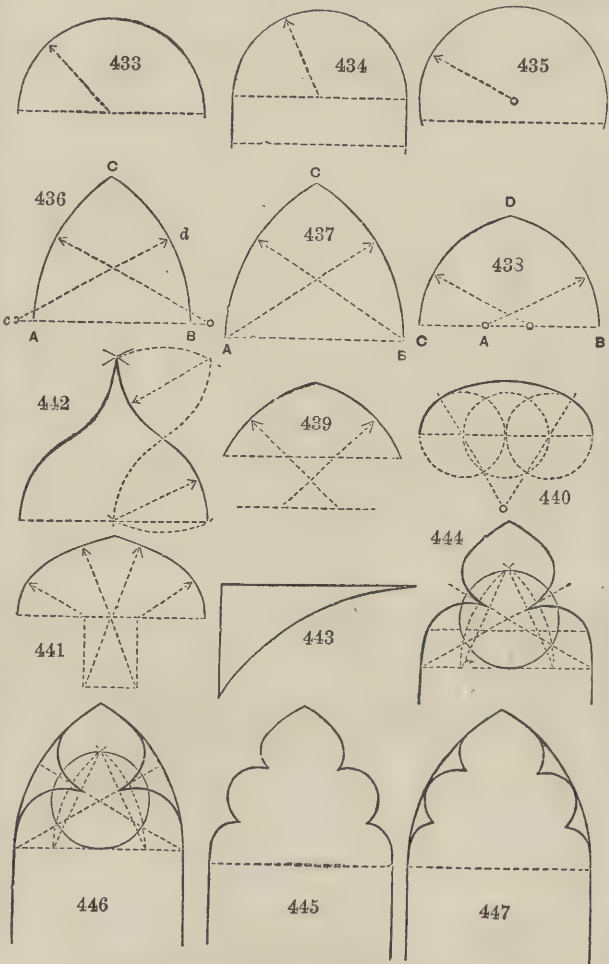
Pointed arches are either—

1. The *lancet arch* (Fig. 436), described about an acute-angled triangle, A B C, the radius (*c d*) being longer than the width of the arch (A B).

2. The *equilateral arch* (Fig. 437), described from two centres (A, B), which form the extremities of the span of the arch, which is thus described about an equilateral triangle, A B C.

3. The *drop arch* (Fig. 438), which has a radius (A B) shorter than the span of the arch, and is thus described about an obtuse-angled triangle (C B D).

All these pointed arches may be of the nature of segmental arches (Fig. 439); that is, having their centres below their springing, as shown in the figure.



Figs. 433-447.—VARIOUS FORMS OF ARCHES.

Mixed arches consist of—

1. The *three-centre* (Fig. 440), which may be called semi-elliptical, since they are constructed on the principle used in drawing the ellipse (or rather the figure approximating to it, since no portion of a true ellipse is really a part of a circle). This method has been shown in lessons on "Practical Geometry applied to Linear Drawing," and its adaptation in the present instance will be seen from the figure.

2. The *four-centred*, or *Tudor arch* (Fig. 441), which has two of its centres in or near the spring, and the two others far below it.

3. The *ogee*, or contrasted arch (Fig. 442), which may be taken as characteristic of the Decorated period. This form of arch has four centres; two in or near the spring, and two above it and reversed.

It has been usual to connect the pointed or lancet arch as the characteristic feature of the Early English period. Mr. Rickman has, however, shown that this is far from being the case; and that whilst every form of arch, with one exception, is found in Early English buildings, so the lancet arch is found in both the succeeding styles; the single exception referred to being the four-centred, or Tudor arch (Fig. 441), which is the peculiar property of the Perpendicular style.

It is, however, true that the lancet arch is the form that most commonly occurs in the windows of this period, and almost every Early English building presents examples of either single, double, or triple lancets. But however frequently this form may have been chosen as the favourite arch for windows, it is certain that a much wider range was allowed for doorways, pier-arches, and arcades; it is not uncommon even to meet with instances of the semi-circular arch in doorways of undoubted Early English date.

The space included between the arch and a rectangle formed at the outside of it, is called a *spandril* (Fig. 443). This is often filled with characteristic ornamentation, which will be described in due course.

We must now speak of another class of arches, the introduction of which is generally referred to the Early English period—viz., *foiled* and *foliated* arches.

A *foiled* arch is formed by uniting three or more small arches together, each springing from the adjacent ones, the result being called a trefoiled, cinque-foiled, etc., according as three, five, or more arches are united in its formation. Thus Fig. 444 is a trefoiled arch, and Fig. 445 a cinque-foiled arch.

A *foliated* arch is a foiled arch placed within a simple arch, as in the following two figures. The arch in Fig. 446 is said to be *trefoliated*, and that in Fig. 447 to be *cinque-foliated.*

This distinction was first pointed out by Professor Willis. It is of considerable importance, since it appears that the foiled arch was introduced at an earlier period than the foliated—the latter being a fuller development of the former.

Foiled arches of a very rude description are occasionally found even in late Norman work, and appear to have been introduced either immediately before or simultaneously with the pointed arch; for in a window at Cambridge there may be seen two foiled lights gathered under a semi-circular head. On the Continent this introduction seems to have taken place rather earlier; but in our own country we have very few instances of foiled arches before the commencement of the thirteenth century.

The foliated arch was at first treated as an independent construction; it was formed of separate voussoirs, and had its own subshafts to support them. In such arches the entire foliation might be removed without affecting the arch enclosing it. This independence of the arch and its foliations became less and less frequent as the style advanced, and ultimately the foliations were reduced to mere excrescences, growing, as it were, out of the enclosing arch. It is in this form alone that they are found in the Decorated and Perpendicular styles.

Foliated arches are sometimes called *feathered.* The points where the foliations of arches meet are called *cusps.*

THE NORMAN PERIOD: ITS MASONRY, ARCHES, MOULDINGS, AND ORNAMENTS.

The Norman style is closely allied to the debased Roman examples of the Eastern and Western Empires, and may be considered as a subdivision of the Romanesque.

This style flourished principally and primarily in Normandy, and hence its name. It became, however, prevalent in countries where the Normans obtained influence, and, amongst others, in England.

The exact date of its introduction into this island has been much disputed. Some historians affirm that it was but a development of the previously existing Saxon; others, that it was introduced by Edward the Confessor; whilst a third party maintain that it was brought over by William the Conqueror.

It is, however, certain that the style became fully developed soon after the Conquest, and it may be said to have prevailed from the middle of the eleventh to the latter part of the twelfth century, or to the close of the reign of Henry II. It is styled generally the English style of the twelfth century, and dates from 1066 to 1170; or, if the Transition or semi-Norman be included, to 1200.

"The Conqueror and his countrymen," says Mr. Nicholson, "were great builders, and the monkish chroniclers tell us that after their arrival churches were erected in almost every village, and monasteries were seen to arise in the towns and cities designed in the new style of architecture. From Doomsday Book we learn that the number of churches had increased to such an extent, that at the time of its compilation there were no less than seventeen hundred in existence."

The plans of the larger churches belonging to this period, such as those of cathedrals and other ecclesiastical establishments, are usually cruciform, having a low, massive tower at the intersection of the nave, choir, and transepts, the choir being frequently terminated with a semi-circular apse.

The aisles of the nave are frequently continued at the side of the choir, and round the apse; and in this case the high altar is situated between the easternmost piers, with a screen or reredos at its back stretching between the piers. Thus a space was left here behind the altar which was named the *retro-altar*, and this allowed of processions passing entirely round the church.

In some instances the choir is surrounded with chapels, having likewise apsidal terminations. The aisles were extremely narrow, sometimes not more than from four to six feet in width. The western façades are occasionally flanked by towers, but more frequently only by turrets or buttresses.

The walls of buildings of this period were of immense thickness; but the masonry was not in all cases solid, being composed of two external walls or facings of "ashlar" work (see "Drawing for Stonemasons"), having the intermediate space filled in with grouted rubble, gravel, flints, etc. Sometimes, however, the walls were made up of solid rubble work, with quoins of ashlar. The joints of ashlar in early work are extremely wide, being frequently as much as an inch in thickness. Many walls of the first description have failed from the outward pressure of the core of loose material; and it is not an unfrequent occurrence to see a Norman wall considerably out of the perpendicular. The introduction of buttresses at a later period led to a great improvement in the construction of walls, adding materially to their efficiency and strength, while at the same time it lessened the consumption of material.

The arches built by the first Norman architects were more or less of a semi-circular form, and of a very plain description. When the wall in which they were constructed was only of a moderate thickness, they generally consisted of a single course of stone or "voussoirs," the edges of which were left square; but, as already stated, the walls were generally of very great thickness, and when this was the case two, three, or more courses of voussoirs were employed, each course receding from the face of the ring of masonry by which it was surrounded.

In the early Norman period the bishops and abbots appear for the most part to have possessed considerable skill in architecture. It is said that no less than fifteen out of the twenty-two English cathedrals contain portions which are undoubtedly of Norman workmanship, the older parts of the cathedrals of Canterbury, Durham, Winchester, Gloucester, Peterborough, Ely, Norwich, Lincoln, and Oxford being all built in what is now called the Norman style.

CHEMISTRY OF THE FINE ARTS.—II.

By Professor CHURCH, Royal Agricultural College, Cirencester.

YELLOW PIGMENTS: YELLOW OCHRE, CHROME YELLOW, COBALT YELLOW, CADMIUM YELLOW—RED PIGMENTS: VERMILION, RED LEAD, VENETIAN RED, MADDER AND COCHINEAL REDS—BLUE PIGMENTS: CŒRULEUM, COBALT BLUE, NATIVE AND ARTIFICIAL ULTRAMARINE, INDIGO, PRUSSIAN BLUE—GREEN PIGMENTS: EMERALD GREEN, VERDIGRIS, VIRIDIAN—BROWN AND BLACK PIGMENTS.

TURNING our attention to yellow pigments, we may first notice yellow ochre, a permanent but somewhat dull colour, which occurs in nature in several tones and hues, and may be made to yield fresh modifications by heat, chemical treatment, or admixture. This pigment was used by the ancient Greeks, and by the Roman artists, being abundantly found in the remains of mural decorations at Pompeii, and having been observed in similar circumstances at Roman stations in England. When pure it is a combination of rust of iron and water, in chemical language a hydrated peroxide of iron, or ferric hydrate. In 100 parts the proportion of iron peroxide in the darker kinds of ochre approaches 70 parts, but the residue of the mineral is made up of minute proportions of many other ingredients besides water. The water essential to the mineral is sometimes as low as 10 per cent. of its weight, and sometimes as high as 30. Those kinds of yellow ochre which are of the desired colour, but contain as little water as possible, are the most suitable for use as pigments. This proportion of water may be at once ascertained, with sufficient accuracy, by heating 100 grains or less of the sample in a porcelain basin over a spirit-lamp, and noting what loss of weight the ochre thus sustains. When the ochre has been mixed artificially with other substances, such as chalk or china-clay, of course this experiment alone is not of much use. And it must be noted that many natural ochres do contain calcium carbonate (carbonate of lime) or aluminium silicate. These substances may be recognised by heating the ochre with a little strong hydrochloric acid: if complete solution be effected with effervescence, the first named substance is present; if a white and gelatinous residue be observed after boiling, then some substance similar to clay is contained in the ochre. Ochre may be reduced in tone by the admixture of any white pigment; or it may be rendered darker and more red in hue by roasting, or by treatment with a weak acid such as vinegar, or by the use of these two last processes in succession.

Chrome yellows are of different tones, ranging from a pale yellow, like that of sulphur, up to a deep orange-red. Of the paler chrome yellows the best is the barium chromate, which sometimes goes under the names of yellow ultramarine and lemon-yellow, a term which is also applied to a lead chromate mixed with lead carbonate and sulphate. The barium chromate is made by precipitating barium chloride with potassium chromate or bichromate. Solutions may be used or the two salts may be finely ground, and then water added in small quantities and the grinding continued. This barium chromate may be washed free from soluble salts, and forms a beautiful yellow pigment (as does also zinc chromate), not liable to change, like the common chrome yellows, which latter are compounds of lead, and therefore capable of being blackened, like white lead, by the action of sulphuretted hydrogen. However, from the brilliancy and purity of the yellow and orange colours afforded by the lead chromates, they are extensively used in the arts, as pigments and as dyes. The commoner chrome yellows are made by treating 4 parts of lead sulphate or chloride with 1 part of red potassium chromate, but the finer preparations are obtained by precipitating the lead acetate in solution. Clay, plaster of Paris, chalk, and many other white substances, are used to an immense extent in adulterating chrome yellow, but the pure substance will be found to dissolve completely and without effervescence, when boiled in dilute nitric acid. Though acted upon by alkalies, and by sulphur compounds, the chromes are not affected by these agents to any appreciable extent when used in oil-painting, especially if they have been properly prepared in a dense condition, and are not used as freshly-made precipitates. A statement has been made that "if an oil picture painted with chromes be washed with an alkaline soap, it is quite certain that some of the chromates will be dissolved." This statement has been found to be directly contradicted by experiment, and it is, therefore, incorrect to condemn the chromes on this score. The

most permanent lead chromates are those of an orange or red colour; they contain a larger proportion of lead than the paler sorts. A fine chrome red may be made by projecting 1 part of dry yellow lead chromate into 5 parts of fused nitre. The fluid mass is poured out, broken up, ground, and washed thoroughly with water. More economical plans depend upon the action of alkalies or powdered litharge, in the presence of water, upon the common yellow chrome. By modifying the temperature, strength of solution, and duration of the operation, any tint of orange or orange-red may be thus obtained.

Cobalt yellow or aureolin is of comparatively recent introduction, and was, indeed, only discovered in 1852. It contains cobalt, potassium, and some oxide of nitrogen, and is often spoken of as a nitrite of the two metals just named. When prepared by the addition of acetic acid and potassium nitrite to a solution of cobalt nitrate, and then keeping the mixture in a warm place for some time, it does not assume its best characteristics as a pigment. When, however, nitric oxide gas is passed into a solution of cobalt nitrate, to which an amount of potash has been added just sufficient to make it slightly alkaline, the product is of good quality. Or potassium nitrite and cobalt nitrate, both in powder, may be heated with a little acetic or nitric acid. Although common aureolin, or cobalt yellow, is blackened by hydrogen sulphide and somewhat acted upon by alkalies, it may be safely used, when of proper density, both in water-colour and oil painting without fear of change. The only pigment which it appears to injure, at all events in oil-painting, is indigo, which then gradually loses its colour, perhaps owing to a reducing action of the aureolin, the substance known to chemists as white or reduced indigo being formed.

Orpiment, or King's yellow, is a beautiful but dangerous pigment: it was employed in ancient art though rarely; its Latin name, *auripigmentum*, or golden paint, is seen in a contracted form in the word *orpiment*. This substance is a compound of arsenic and sulphur, which occurs in nature as a mineral, and may be made artificially. As it is made, or may be made, by the action of sulphuretted hydrogen, that gas does not change its colour, but it is itself liable to change the colour of white lead and some other pigments. King's yellow when pure is perfectly volatile on heating it on a piece of porcelain, and does not become paler or darker when warmed with dilute hydrochloric acid.

Cadmium yellow is the sulphide of the metal, and possesses a most intense orange-yellow colour. Though sold at a high price, the metal cadmium is not really so costly as to prevent this splendid and permanent pigment from being much more largely employed than at present. It must be prepared and washed with great care if it is to be used with white lead, and there seems to be some reason to fear that even then the sulphur in this compound is capable of effecting changes in lead pigments with which it may be mixed. By varying the temperature and strength of the cadmium chloride solution used in preparing this colour, or by making it in the dry way with a cadmium salt and an alkaline sulphide, or with cadmium oxide and sulphur, its tint may be varied from a rich yellow to an orange-red.

Other mineral yellows are of less importance: among them are certain lead oxychlorides and oxysulphates; a basic lead antimoniate called Naples yellow; and also lead arseniate and iodide. But two yellows of organic origin must not be omitted here, since both of them are useful colours in water-colour painting. *Purree* or Indian yellow is the magnesium salt of a curious acid called the euxanthic. Its colour may be greatly improved by dissolving the crude Indian yellow of commerce in boiling dilute hydrochloric acid, after having washed it with hot water, filtering the solution, and adding a little ammonia to the hot liquid. The yellow crystalline powder which will be found deposited from the liquid when it has remained twenty-four hours, will prove on grinding to have a richer colour than the original *purree*. Gamboge is a rich yellow pigment belonging to the gum resins. Its essential constituent is a brightly coloured yellow resin, which when in films has a hyacinth-red colour, and is insoluble in water, but soluble in spirits of wine and in alkalies. Good gamboge contains 70 per cent. of this ingredient. The pipe gamboge of Siam is the best kind.

Amongst red pigments we may first notice vermilion, although it is by no means a perfectly satisfactory one. Vermilion is the red variety of mercuric sulphide, and occurs naturally as the mineral cinnabar. It may be made artificially by subliming the black amorphous sulphide of mercury, which thereby undergoes a molecular, not a chemical change, and becomes crystalline and red; or it may be made by grinding sulphur and mercury or its oxide together for a long while, and then warming the mixture in the presence of some caustic potash solution for many hours at a temperature of 45° to 50° Centigrade. When any kind of mercuric sulphide, black or red, is mixed with 1 per cent. of antimonious sulphide, and sublimed, it yields a product which may be turned into a splendid crimson-red vermilion by being finely ground and then digested repeatedly with liver of sulphur in solution, and then washed and digested with hydrochloric acid; afterwards it is to be washed with pure water and dried. Thus prepared, the product is equal to the best Chinese vermilion. Adulterations in vermilion are numerous, but may be easily detected. Red lead remains behind, as the yellow oxide, when the impure vermilion is strongly heated. Red ochres and burnt clays remain unchanged during this process. Red resins, such as that known as dragon's blood, may be removed from vermilion by warming it with strong spirits of wine. It is, however, found that the saturation of finely-prepared and ground vermilion with a solution of this red resin, and the subsequent drying of the material, protects this pigment to some extent from that liability to become dull and, as it were, tarnished in this lapse of time, which so seriously detracts from its value, when used with size, gum, etc., in distemper and water-colour painting. As the beauty of the tint of vermilion depends upon a nicely adjusted molecular state, it is not difficult to explain its proneness to change.

Cinnabar or vermilion was known to the ancient artists. By Pliny and Vitruvius it is also called minium, which now signifies red lead exclusively. Vermilion is derived from *vermiculus*, a form of the word *vermes*, a worm; it was originally applied to the *kermes*, an insect, a species of *coccus*, found in the south of Europe, and yielding a red dye inferior to true cochineal.

It is unnecessary to say much about red lead, which is an oxide of lead containing 3 atoms of lead and 4 of oxygen. It is very heavy, and difficult to mix with other pigments, or to use safely in decoration or in painting.

Venetian red and Indian red, and numerous other colours of similar hues, are really nothing more than ferric oxide or peroxide of iron, more or less pure. They are excellent and permanent colours which have been abundantly employed in painting from the earliest ages, and are found by long experience to merit entire confidence. *Rubrica* is the Latin name for red ochre, of which that from the isle of Lemnos was most esteemed. All the ferruginous reds which go under the names of light red, Mars red, Mars violet, Venetian red, etc., are distinguished from the yellow and brown ochres by their greater purity, and the absence of water in combination, although they may contain a small quantity of moisture derived from the atmosphere. One of the best of all these native iron reds is a remarkably rich and deep red hæmatite which goes in commerce under the name of Wharton's hæmatite. It contains no less than 94·7 per cent. of pure ferric oxide. We have already mentioned the methods by which ochres, whether yellow or red, may be changed in tint.

We must dismiss the vegetable and animal reds with a few words about the most important of them, namely, those derived from madder and cochineal respectively. The colours from the root of the madder plant, *Rubia tinctorum*, are more numerous when employed in dyeing than in painting. But if the range of the madder pigments is limited, their beauty and comparative stability render them indispensable to the artist. The madder lakes are prepared by precipitating the aqueous extract of madder or of its derivatives with salts of aluminium, or rarely, with iron and tin compounds.

Some of the residual matters obtained in the preparation of the various madder derivatives used in dyeing may be made to yield, by exhaustion with boiling water, a liquor, from which alum or milk of lime precipitates beautiful pink or violet lakes. A good method of preparing a madder lake from the root is to take 4 parts by weight of the root, and thoroughly exhaust them with repeated agitation and pounding with small portions of pure cold water. When all colour that can be thus extracted is removed, add 3 ounces of alum in solution, and afterwards enough solution of potassium carbonate to precipitate all the alumina present. The madder lake thus precipitated is to be filtered off, washed, and dried. Lakes of different tints may be made from the exhausted residue of the above operation by boiling it with water, and adding alum and an alkaline carbonate

as above described. The colouring matters of madder, which exist in part only ready formed in the root, are known as alizarine and purpurine: the former of these has been lately made artificially from one of the coal-tar products, anthracene, and is capable of yielding a fine series of colouring substances when united with various oxides. Lakes may be prepared from almost all vegetable colouring matters by the process described above—yellow lake, for instance, from fustic, turmeric, annatto, quercitron, and the berries of certain species of Rhamnus. The cochineal lakes are red, and are known as scarlet and crimson lakes, and as carmine. In order to prepare the lakes of cochineal, the dried insects, *Coccus cacti*, are exhausted with cold or hot water, and the clear extract precipitated with an alkaline carbonate and alum. Carmine, on the other hand, is not a true lake, but is the colouring matter of the cochineal mixed with a little albuminoid substance and fat, coagulated and carried down together, by the addition, to the cochineal extract, of alum or cream of tartar, or salt of sorrel, without an alkali. Pure carmine, unlike the lakes, is soluble in liquor ammoniæ. The commoner cochineal colours are constantly adulterated with preparations of Brazil wood, etc., or else are made from the residues and inferior qualities of cochineal. From the researches of Warren De la Rue it has been ascertained that the true colouring principle of cochineal is an acid, called coccasic acid. And it is not improbable that some of the pure salts of this acid will turn out to be the most permanent forms in which to employ the colouring matter of cochineal.

Lakes and other preparations of lac, madder, and of Brazil wood (from India), were known to the mediæval illuminators and artists. In a document of the reign of Edward III. a sinopre or cynople is spoken of, which seems to have been a madder lake.

Blue pigments in ancient times appear to have been very numerous. Cœruleum, in later times azura or lazura, was the blue mineral known now as chessylite, a mixed carbonate and hydrate of copper; in Pompeian art it was largely employed, as well as another blue, a smalt made by grinding a blue glass coloured either by copper or cobalt. "Indebras" or indigo from Bagdad is spoken of in an English document dated 1228, but it is certain that similar blue vegetable preparations were known to the ancients. Indigo has been found on Egyptian mummy cloths, and is mentioned by Pliny under the name of *indicum.* The modern cœruleum blue is a cobalt stannate, and contains, along with some silica and gypsum, 3 molecules of cobalt oxide to 4 of stannic oxide. It is an excellent and permanent blue with a slight greenish shade, and retains its blue tint, unlike cobalt and ultramarine, when seen by artificial light.

Cobalt blue, properly so called, is prepared by mixing a pure solution of a cobalt salt with a solution of pure alum, and precipitating the mixture with an alkaline carbonate. The precipitate, after thorough washing, is strongly ignited, and forms a rich and permanent blue pigment. Other cobalt blues are in use, but, with one exception, they are less permanent than that just mentioned. Smalt, essentially a cobalt and potassium silicate, is that exception. It is often called cobalt blue, but is not so perfect a colour as the true compound above described. It is a deep blue glass, ground up into a powder, and is perfectly unchangeable by time. It is made extensively in Saxony, by fusing roasted cobalt ore with quartz and potassium carbonate.

The magnificent blue derived from the lapis-lazuli was and is highly esteemed as a pure and permanent pigment. Its preparation from the mineral is tedious and costly. So highly was the natural ultramarine valued by the painters of the best period of Italian art, that before undertaking the grinding of a native lump of the lapis they sometimes made vows and offered special prayers for the success of the work. Now, however, that chemists have succeeded in rivalling the native pigment by a composition which is practically almost identical with it in composition, we may obtain this magnificent blue colour at an insignificant cost. China clay, sodium sulphate, charcoal, and soda are calcined together for some hours in a closed crucible, and the green mass thus obtained is, after grinding and addition of sulphur, once more ignited: it then becomes blue. The blue colour of artificial ultramarine is readily discharged by hydrochloric and other acids. And it has been observed that when mixed with white lead, as in painting skies, the mixed pigments often change from a pale blue to a lilac or grey hue, probably owing to the action of some sulphur compound in the ultramarine upon the lead.

Indigo, a pigment derived from a colourless compound existing in the *Isatis tinctoria, Indigofera tinctoria*, and *I. anil*, besides several other plants, differs from the pigments previously studied in containing the element nitrogen. Commercial indigo contains many impurities, and not more than 50 to 60 per cent. of the real colouring matter. It may be purified by reducing it to the condition of the colourless or white indigo, and then exposing the solution of that substance to the air, when a blue powder falls. Or the commercial indigo may be pounded and successively exhausted with cold water, dilute hydrochloric acid, hot water, and alcohol. If plaster of Paris 2 parts, and finely powdered indigo 1 part, be made into thin cakes, dried thoroughly, and then heated on an iron plate, pure crystallised indigo sublimes, and may be scraped off the cakes. Or the indigo may be dissolved in Nordhausen or fuming oil of vitrol, by which two or more complex acid bodies are produced, the salts of which may be employed as pigments. Pure indigo dissolves perfectly, without residue, in cold fuming oil of vitrol. It is scarcely necessary to say that the best and most trustworthy preparations of indigo for painting are those which contain this substance in the greatest purity.

Prussian blue and Turnbull's blue are compounds of cyanogen and iron. Prussian blue is best formed by gradually adding a solution of yellow prussiate of potash, potassium ferrocyanide, to excess of ferric chloride, and thoroughly washing the precipitate of Prussian blue, after having digested it for some time, with a fresh portion of ferric chloride. A similar blue may be made by precipitating ferrous sulphate with yellow prussiate, and oxidising the pale blue precipitate by exposure to the air, or by nitric acid. All the blues of this class should be thoroughly washed from soluble salts, especially if they are to be used in oil-painting. Prussian blue, though destroyed by alkalies, resists the action of acids. If ground with its own weight of oxalic acid, it dissolves, forming a blue paste soluble in water. A soluble Prussian blue may be made, but it is inferior to those already described.

Amongst green pigments one of the most vivid is emerald green: it is, however, poisonous, as it contains both arsenic and copper. It is also inadmissible in silicious painting, is readily darkened by sulphuretted hydrogen, and is similarly affected by some samples of ultramarine and of cadmium yellow. This emerald green, or Schweinfurt green, is a compound related at once to verdigris and to Scheele's green, being a mixed acetate and arsenite, while the latter is a copper arsenite. Verdigris itself is also used as a pigment; it is a basic copper acetate, containing, when of good quality, about half its weight of copper oxide. Besides verdigris (*Vert de Grèce*) the ancients possessed many other green pigments, such as the copper carbonate and hydrate known now as malachite, and still used in this way occasionally; and also various kinds of "green earth," terre verte, minerals containing iron protoxide and of a dull hue. But the modern invention of chrome greens has displaced many of the older and inferior pigments. We refer, of course, to the true chrome greens, and not to the fugitive mixtures, sometimes so called, of chrome yellows with blue pigments. The older chromium greens consisted simply of the sesquioxide of that metal, and, while generally very dull indeed, attained but rarely anything approaching a pure hue. These dry or anhydrous chromium oxides, prepared by ignition of the various salts of chromic acid, vary much in quality, the best being made by heating mercurous chromate in a closed crucible till all volatile matter has been driven off. But the hydrated chromium oxides are of far finer and more translucent hues than the dry. One of the best of these is Guignet's green, introduced into this country as viridian. It is, in reality, a compound of chromium sesquioxide, water, and boracic acid, containing about $\frac{3}{4}$ of its weight of the first-named substance, and is prepared by calcining together 3 parts of crystallised boracic acid and 1 of potassium bichromate. The product is ground and washed, and constitutes a splendid and permanent pigment. When ammonium phosphate and potassium bichromate are heated together to 180° Cent., they yield another fine green, Arnaudon's green.

It is scarcely necessary to add anything concerning brown and black pigments, beyond the statement that the former, such as amber or raw sienna, consist chiefly of ochres and of vegetable lakes already described; while the latter are either permanent preparations of carbon—as, for instance, lamp-black, Indian ink, and ivory black—or else are organic products such as sepia, the stability of which secretion is pretty well assured from

the observation that the ink-bag of the fossil cuttle-fish has been found to yield as excellent a sepia as that of the *Sepia officinalis* now living. Brown and black pigments containing bitumen are very treacherous in use, owing to the marked effects of temperature upon such materials.

We have not alluded as yet to any of the beautiful "aniline colours" or "coal-tar colours," now so extensively employed in dyeing, since, for the most part, they do not possess a sufficient degree of permanence to be safely used in painting. Yet it is possible that a few of these magnificent colouring matters, related to mauve, rosaniline, peonine, azuline, Manchester yellow, emeraldine, etc., may hereafter be found capable of use in painting. Experiment in this direction is greatly needed, yet it must be owned that there are other difficulties besides that of want of permanence to be surmounted. These colours are not usually soluble in any available solvent, nor do they show their hues when merely ground. So a white basis is generally necessary. Pure whitening may be used successfully for obtaining a violet tint with mauve. A strong hot alcoholic tincture of mauve is to be poured upon warm and dry whitening, which is then dried and ground. The process is repeated till sufficient depth of tone is obtained. This method is merely here suggested for a more extended trial, and with other coal-tar pigments, since the mauve pigment thus prepared has changed, though only to a slight extent, since it was first used in 1860.

SANITARY ENGINEERING.—XII.

VENTILATION.

Few subjects have within the last few years attracted more public attention than ventilation, or, as we may term it, the theory of supplying fresh wholesome air to crowded rooms, where either from the necessities of their occupation, when used for manufacturing purposes, or the accidental circumstances of their public use for meetings, etc., the consumption of wholesome atmospheric air is greater than the supply; but there is the no less important question previously arising as to the best method of ventilating or supplying fresh air to ordinary living rooms, so as to secure the maximum of comfort with the minimum of inconvenience. We do not propose to go very deeply into the scientific aspects of the question: in our present paper we shall confine ourselves to a general statement of what are the general principles to be observed, and a description of some of the best modern appliances for the purpose; while in some subsequent articles we may deal with the subject as applied to public buildings with large audiences and others, where a special class of difficulties has to be dealt with—*e.g.*, hospitals, where, in addition to the ordinary deterioration of the atmosphere by respiration, foul air and the seeds of absolute disease have to be encountered and remedied.

In some previous papers on Warming, we have described the way in which heat is made available to secure, by means of water, a circulation: the first principle being that hot water is lighter than cold, and will always rise through it to the surface; and a wider and more extended application of the same principle—*i.e.*, that hot air is lighter than cold, and will rise through it—is the base of all efficient systems of ventilation, with this difference, however, that the hot air is not available for return purposes, as in the case of hot water, but has to be got rid of, together with, in many cases, a considerable volume of comparative impurity arising from respiration and the proceeds of combustion.

As a familiar illustration of the natural consequence of insufficient ventilation in ordinary dwelling-houses, we may venture to remind our readers, many of whom have doubtless experienced the effect, that when by some accident it becomes necessary either to reach a book from a lofty shelf, or, for some necessary attention to a lamp, to climb into a position above the top of the door of an ordinary room, if the window happen to be closed, a sensation is at once experienced as if a different atmosphere were entered; there is a rise of temperature of many degrees, and, especially if the room is lighted by gas, a sense of discomfort from the presence of vitiated air, the product of combustion, is felt; if at the same time the door be set ajar, a candle held at the top will indicate a strong *outward* current of air, and when the same candle is held at the bottom a strong *inward* current, the top of the room above the door forming a sort of inverted receiver for the vitiated air of the apartment. We take a simple case first, as an illustration of the difficulties to be dealt with, which are similar in most cases.

In winter we suppose, of course, a fire in the room; this creates a strong up-draught in the chimney, and removes from the lower part of the room all vitiated air; but the modern method of stove construction brings the fire within a very short distance of the floor, and therefore this influence can scarcely be said to extend above the level of the mantelpiece; from this level to about, say, 7 feet 6 inches high, the air of the room is under the control of the door; and above that level, when there is no means of opening a window, and no artificial means of ventilation provided, the air becomes, as we have said, a permanent hot-air bath. The temperature to be maintained in any ordinary sitting-room is of course most variable, according to the habits of its inmates, and the warmth or otherwise of the external air. Some families are constitutionally tender, and others, to use a common phrase, cannot have too much fresh air; but each and all, by attention to a few simple rules, can regulate the temperature of their rooms to their own liking.

Our forefathers had never any trouble with the question of ventilation. The old system of wainscoting walls provided for the admission of air by innumerable crevices, and for its exit in the same way; and if the power of the fire was sufficient to warm the room, nature did the rest; but in our modern days our plastered ceilings and walls effectually prevent any such spontaneous result.

Englishmen, as a rule, like fresh air, and Continental travellers frequently complain of the closeness engendered by the radiating stoves in use abroad, and often in railway carriages there is the greatest objection on the part of the "natives" to letting down a window: the reason for this we do not intend to assign; we simply state it as a well-known fact—they are terribly afraid of draughts. At the same time there is no more common cause of cold than an open window, or, as it is commonly called, sitting in a draught.

We will now return to a simple statement of the objects to be obtained by ordinary domestic ventilation. The hot air at the top of the room, as a usual rule, is impure, and has to be got rid of; and the fresh air, which is the cold external air, has to be admitted without creating such a draught as may be either unpleasant or injurious. The obvious conclusion is that the hot air must be allowed to escape at the top of the room, and the fresh air must be admitted from the bottom; the intermediate action of the fire being always taken into account: as a general rule, a *down draught* from a ventilator in the upper part of the room is a mistake, and likely to be mischievous. As a further homely illustration of these general principles, we may mention the not uncommon case of a fire which will not draw when first lighted, and the chimney smokes: by opening a door or a window, or both as the case may be, the requisite supply of fresh air is obtained, and everything goes on satisfactorily.

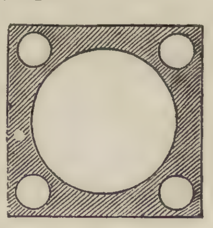


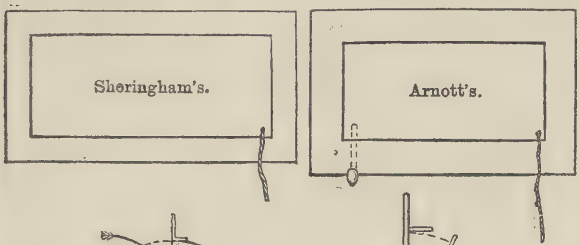
Fig. 1.

The actual demand of a fire for a supply from the external air is well exemplified by an invention recently brought out, and which, we believe, is the subject of a patent. A flue is constructed of terra-cotta, circular in the central opening, but enclosed in a square envelope, as we may term it, the spandrils at each corner being independent of the flue, but forming separate air-ducts, communicating with the atmosphere of the room: a section of this is shown in Fig. 1. It might be surmised that the heat of the flue diffused through the surrounding ducts would cause an upward current, and so draw from the room the air, especially from the upper portion: it is, however, found in practice that exactly the converse result takes place, and that the ordinary draught of the fire, when a room is in its normal state, is sufficient to bring a very marked *down draught* through these auxiliary flues. In a previous paper on heating by warm air, we alluded to a system by which the outer iron case of the stove, specially constructed for the purpose, had a direct communication, by means of a channel or pipe, with the external air, which was by this means introduced into the room at a higher temperature; and this is a system the adoption of which may be safely recommended.

In any case, if the stove be not constructed for the purpose, a small flue communicating with the outside of the building and

with openings provided either in the hearth, or in the jambs of the chimney at the level of the fire, will be found a most important assistance to a smoky chimney, and have a generally beneficial effect upon the atmosphere of the room. An air-brick introduced in the wall between floor and ceiling, and small holes dispersed at intervals along the side of the room, will also assist in providing fresh air without creating a draught. Another plan is to introduce a panel of perforated zinc in the lower panel, or even the bottom rail of the door, a plan often adopted with advantage; and the skirting of the room, if of wood, may readily be made available in a similar way. Provision being made for the admission of fresh air from below, which should be by small openings, so as to avoid the influx of such a body of air as would create a sensible draught, the next step is to provide for the removal of the vitiated and heated air above.

Perhaps one of the best known and most generally adopted expedients for this purpose is Dr. Arnott's ventilator: this is a small valve, generally about 9 inches long and about 6 inches high, opening into the room just below the ceiling level, and communicating with the chimney, and is generally made of metal of ornamental character. In some recent improvements, however, light sheets of talc in metal frames have been adopted: the valve is hung from the bottom, and is provided with a small balance weight adjustable by a screw; this should be so nicely set, that when the temperature of a room rises above a certain point, the valve should open and allow the vitiated air to escape up the chimney, closing itself again by an automatic action when the balance is restored; they are also provided with lines, which



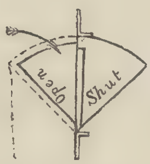


Fig. 3.

Fig. 2.

enable them to be permanently closed when not required—*i.e.* when there is no fire—as they are entirely dependent for their action upon the draught of the chimney.

Another class of ventilator, commonly called Sheringham's, is constructed with a hopper, which is also controlled by a line, and when open falls forward into the room in the shape of a small quadrant (Fig. 3). The above figures will explain the comparative action of the two, Sheringham's ventilator being intended to communicate with the external air.

The object of this latter construction is to prevent down draughts; but much depends upon the judgment exercised in its use, as should the opening be allowed to be larger than is sufficient to allow of the exit of the heated air, a volume of cold air will certainly rush in, and a down draught result.

This will especially be the case should the adits provided for fresh air from the lower part of the room be insufficient to supply what we may call a free draught to the fire: the heated upward current being once well established in the flue, will certainly draw its supply from any available point, and should the demand be made upon the ventilator, a draught more or less direct from the opening to the fire will be the result.

One very simple and ingenious plan we have seen adopted for introducing fresh air at what we may call the intermediate level with satisfactory results. The bottom rail of the ordinary window sash is made of double thickness or depth, all the other proportions remaining the same, the effect being that the sash can be lifted from one inch and a half to two inches without admitting air at the level of the sill; this affords a means of ingress for cold air, or egress for hot, according to circumstances. This method is explained by the sketch in Fig. 4.

Another very efficient and easily adopted expedient for providing ventilation without direct draught, is by means of a telescopic tube of perforated zinc (Fig. 5), which may be affixed to any window when wanted, and removed when not required: as it can be adjusted to any length it will fit any window, and provides a

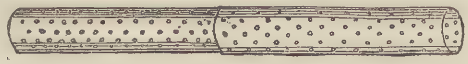


Fig. 5.

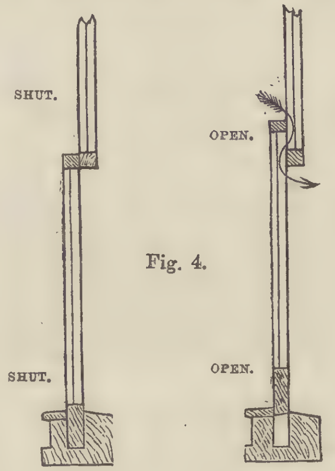


Fig. 4.

Fig. 6.

ready means for the exit of hot air; it is made in two pieces which slide one within the other. The upper sash has to be pulled down three or four inches, the tube introduced between the beads, when the sash being simply pushed up against it holds it in its place.

Moore's ventilator is an arrangement for the admission of fresh air without loss of light (Fig. 6). One or more of the panes of glass of the window, as the case may require, are occupied by strips of glass which overlap each other, and are hinged so as to be opened at pleasure, while the louvre-like arrangement thoroughly excludes the weather. By lines adjusted for these purposes, the ventilators are thoroughly under control, and the temperature can be regulated with great nicety.

Sometimes, with a view to the same object, what is called a "hit or miss" ventilator is adopted (Fig. 7): this form of ventilator is generally made circular, and consists of two plates of glass perforated with holes of any size, which exactly correspond with either, and have spaces between them of rather greater area than the openings themselves: by means of a pin and small handle, one of the plates of glass is movable, the other being fixed. When so adjusted that the openings coincide, the full amount of ventilation is obtained; when the contrary is the case, the air is thoroughly excluded. In the sketch the ventilator is supposed to be closed, the dark lines representing the openings in the one plate, and the dotted lines those in the other: it will be seen that by about one-eighth of a revolution the openings in the two plates are made to coincide, and by an intermediate position a regulated result may be obtained.

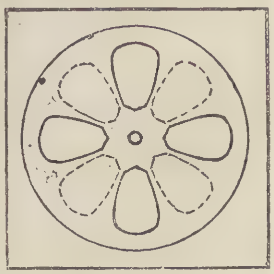


Fig. 7.

In the construction of the cornice of an ordinary room, openings may be provided for ventilation with good effect, and ornamental centre-flowers may be utilised for the same purpose, and there are also many other inventions of a similar character which our space will not allow us to notice. Our own view is that the general principle stated at the commencement, the distributed admission of fresh air at a low level, and the regulated escape of heated air at the upper level, the balance of circulation being maintained with judgment, will be found, with the aid of the many appliances available for that purpose, the true system of comfort in domestic ventilation.

SEATS OF INDUSTRY.—XIX.

KIDDERMINSTER.

BY WILLIAM WATT WEBSTER.

The manufacture of carpets on a large scale is an industry of comparatively recent origin. Till about the middle of the last century, the consumption of carpets in Great Britain was exceedingly trifling, and a very few generations ago they were only partially used even in the houses of the aristocracy and gentry. At the present time England and America are the only countries where carpets are in almost universal use, and, consequently, where their manufacture has attained any considerable importance. In 1735, carpet manufacturing was first introduced into Kidderminster, and from that date to this the name of the town has been intimately associated with the English carpet trade.

Kidderminster is a municipal and parliamentary borough in the county of Worcester, situated on the river Stour, about four miles above its junction with the Severn, at a distance of fifteen miles to the north of Worcester, and 125 miles to the north-west of London. The town is built on rising ground on the banks of the Stour, and was called *Chiderminster* by the Saxons, *Chid* in British signifying a hill, and *dur*, water. Little is known of the history of the place previous to the reign of Henry II., except that it was a royal manor. That sovereign gave it to the Bassetts, from whom it passed to the Beauchamps, Nevilles, Cookseys, Blounts, Foleys, and to Waller the poet, and it is now the property of the Earl of Dudley. In the time of Edward I. Kidderminster returned members to Parliament, and in the beginning of the sixteenth century it was noted for the manufacture of broadcloth. The earliest charter of incorporation that has been discovered dates from the twelfth year of Charles I., but it claims to be a borough by prescription. In the eighth year of George IV.'s reign Kidderminster obtained a new charter for the acquisition of lands, and an increase in the number of magistrates, which had been limited by the previous charter to two. The right of the borough to return members to Parliament which had lapsed through desuetude, was renewed by the Reform Bill of 1832, and since that date Kidderminster has sent one member to the House of Commons. Under the Municipal Act of 1835, the town was divided into three wards, and placed under the government of a mayor, six aldermen, and eighteen councillors. Kidderminster was celebrated for its manufacture of worsted, or of worsted and silk goods, and subsequently for bombazines, plushes, and poplins, before it became famous for its carpets.

About the year 1775, forty years after the manufacture of carpets had been introduced into the town, there were in Kidderminster 1,700 silk and worsted looms, each employing one weaver, and 250 carpet looms, each employing a man and a boy, the total number of persons employed in both branches of manufacture being about 5,000. By the year 1830 the number of silk and worsted looms was reduced to 700, while the number of carpet looms had increased to about 1,000. In 1838, the hand-loom weavers' commissioner reported that there were in Kidderminster in that year 2,021 carpet looms in operation, besides 80 looms for bombazines, and about 400 looms unemployed. From the parliamentary returns of mills and factories of the same date we learn that there were then in the town and neighbourhood six worsted mills employing a total of 622 hands, 1,765 looms for making Brussels carpets, 210 looms for Scotch carpets, and 45 for Venetian carpets. The total number of persons employed in the weaving trade at Kidderminster was at that time stated to be 1,905 men, 351 women, and 1,760 children; in all, 4,016. In 1801, the population of Kidderminster numbered 6,110; in 1811, 8,039; in 1821, 10,709; and in 1831, 14,981. In 1851, the town contained 18,462 inhabitants, but by 1861 its population had declined to 15,399, while in 1871 it had increased to 20,800.

The hand-loom weavers' commissioner, from whose report a quotation has already been made, furnishes some interesting information in reference to the reductions that took place in the wages paid to the weavers of Kidderminster, during the twelve years that preceded a great struggle between the workmen and their masters in 1828, which is the most memorable event in the industrial annals of the town. "I find," he says, "that in 1816 wages were reduced 17 per cent., and in 1828 a further reduction of 17 per cent., and even of 20 per cent. in comber-work took place; say about 34 per cent. total reduction since the termination of the war. Trade has suffered," he adds, "not in the quantity produced, but in the decrease of profits." In the spring of 1821, the masters lowered the rate of wages from 1s. to 10d. per yard, and a strike ensued which lasted from March to August, entailing terrible disasters on the employés, great loss to the employers, and severe, permanent injury to the trade of the town. Previous to the strike, many of the weavers had little sums of money laid aside, and owned the cottages in which they lived. Benefit clubs had also been established, and were in a prosperous condition. But when the struggle was over the great majority had spent their savings, sold their property, pawned their furniture, while many had migrated, and those who remained returned to their work listless and penniless. Orders that had previously been executed in Kidderminster were sent to Scotland, and many of the weavers went there and found employment. The prolonged poverty the workmen endured is said to have exercised a deteriorating influence on their character, and the Kidderminster weavers have never regained the position they held before this strike. Although the masters won the day, they irrecoverably lost a considerable portion of their trade, and their victory may be described in the Duke of Wellington's words, as hardly less disastrous than a defeat would have been.

The principal centres of carpet manufacture in England are, Kidderminster; Wilton, in Wiltshire; Axminster, in Devonshire; Yorkshire; and in Scotland, Kilmarnock, Edinburgh, and Stirling. About ten years ago, the number of carpet looms in Great Britain was estimated at about 4,000, and the yearly produce at about £1,000,000. In the year 1866, 7,600,511 yards of carpets and druggets, manufactured in the United Kingdom, were exported, the total value being about £1,217,682. The greater part of the carpets exported from Great Britain are sent to the United States of America. A few carpets of exquisite patterns and colours are still imported into this country from Turkey and Persia, but they are now nearly equalled by the best of the carpets produced at Axminster, at Wilton, and in Scotland.

The carpet known by the name of Kidderminster is still manufactured in the town, but it is now produced in much larger quantities in Scotland and in Yorkshire. It is the Brussels and Wilton carpets, which are composed of linen and worsted, that now constitute the most important branches of the trade carried on in Kidderminster, but tapestry or Venetian carpets are also made there in considerable quantities. The manufacture of the cut-pile or Wilton carpet was introduced into the town in 1749. Kidderminster has a high reputation for the excellence of its carpet fabrics, the elegance of the designs, and the durability and brilliancy of the colours. Various other kinds of woollen goods are manufactured in Kidderminster, and there are several extensive worsted spinning-mills in the town and the vicinity. Large quantities of finger-rings, damask silk goods (used in upholstery), silk coverings for buttons, and waistcoat pieces are also made in Kidderminster, and it possesses iron-foundries, malting-houses, breweries, a paper mill, wire-works, brick-fields, dye-works, and tanneries.

The town of Kidderminster consists principally of small, humble houses, and the streets are irregularly laid out, but clean, well paved, and well lighted. Among the public buildings, the most noteworthy are the Town Hall, a large brick structure with police station and prison cells attached; and the Public Rooms and Corn Exchange, a noble pile completed in 1855, containing a Music Hall, an Exchange, rooms for a Free Library, a School of Design, a news-room, class-rooms, etc. The parish church, dedicated to St. Mary, is a spacious edifice, with a square tower supported by massive buttresses, crowned with decorated battlements and pinnacles, and containing a peal of eight bells. The building is adorned with several ancient brasses and effigies—one being that of a Crusader—and with monuments of members of the Blount and Cooksey families, and one to the father of Lord Somers. Over the altar of St. George's Church, which was erected in 1823, under the sanction of the Commissioners for Building New Churches and Chapels, at a cost of about £16,400, there is a beautiful specimen of Kidderminster carpet-weaving, representing the descent from the cross. The Baptists, the Independents, the Roman Catholics, the Wesleyans, the Primitive Methodists, and the Unitarians have all chapels in Kidderminster. Richard Baxter, the celebrated Nonconformist divine, held the living of Kidderminster until the time of the

Restoration; and when the corporation chest was opened in 1838, it was found to contain, among other curious relics and documents, a very old edition of "Baxter's Saints' Rest," on the title-page of which was the following inscription in the author's handwriting:—"This book being devoted, as to the service of the Church in general, so to the church at Kederminster, the author desires that this book may still be kept in the custodye of the high bayliffes, and entreateth them carefully to read and practise it, and beseecheth the Lord to bless it to their true reformation, consolation, and salvation.—Richard Baxter." The Free Grammar School of Kidderminster, founded in the reign of Charles I., has a revenue of upwards of £500 per annum. Clare's Almshouse, founded by Sir Ralph Clare in 1670, and Blount's Almshouse, founded by Sir Edward Blount in 1630, are the most important charities in the town. At Roundhill, about half a mile from Kidderminster, there is a chalybeate spring, and there is another strongly impregnated at Sandburn. On Burlish Common there is a dropping well, which was once celebrated for the cure of disorders of the eye.

PRINCIPLES OF DESIGN.—XXIV.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

GLASS.

When speaking of earthenware, I insisted upon the desirability of using every material in the easiest and most natural manner, and I illustrated my meaning by saying that glass had a molten condition as well as a solid state, and that while in the molten condition it can be "blown" into forms of exquisite beauty. Glass-blowing is an operation of skill, and an operation in which natural laws come to our aid, and I cannot too strongly repeat my statement that every material should be "worked" in the most simple and befitting manner; and I think that our consideration of the formation of glass vessels will render the reasonableness of my demand apparent.

Let a portion of molten glass be gathered upon the end of a metal pipe, and blown into a bubble while the pipe drops vertically from the mouth of the operator, and a flask is formed such as is used for the conveyance of olive oil (Fig. 92); and what vessel could be more beautiful than such a flask? Its grace of form is obvious; the delicate curvature of its sides, the gentle swelling of the bulb, and the beautifully rounded base, all manifest beauty.

Here we get a vessel formed for us almost wholly by nature. It is the attraction of gravitation which converts what would be a mere bubble, or hollow sphere of glass, into a gracefully elongated and delicately-shaped flask. This may be taken as a principle, that whenever a material is capable of being "worked" in a manner which will so secure the operation of natural laws as to modify the shapes of the objects into which it is formed, it is very desirable that we avail ourselves of such a means of formation, for the operation of the laws of gravitation and similar forces upon plastic matter is calculated to give beauty of form.

When clay is worked upon the potter's wheel, it is shaped by the operator's skill, and is sufficiently stiff to retain the shape given to it to a very considerable extent, yet the operation of gravitation upon it, so long as it has any plasticity whatever, is calculated to secure delicacy of form. This rule should ever be remembered by the art-student—that a curve is beautiful just as its origin is difficult to detect (see Vol. I., page 279). In the formation of vases, bottles, etc., knowledge of this law is very important, and the operation of gravity upon hollow plastic vessels is calculated to give to their curves subtlety (intricate beauty) of character. Having arranged that the material shall be worked in the manner most befitting its nature, we must next consider what purpose the object to be formed is intended to serve.

Take a common hock-bottle (Fig. 93) and consider it. What is wanted is a vessel such as will stand, in which wine can be stored. It must have a strong neck, so that a cork may be driven in without splitting it, and must be formed of a material that is not absorbent. Glass, as a material, admirably answers the want, and this bottle is capable of storing wine; it will stand, and has a rim around the neck such as gives to it strength. But, besides serving the requirements named, it is both easily formed and is beautiful. The designer must be a utilitarian, but he must be an artist also. We must have useful vessels, but the objects with which we are to surround ourselves must likewise be beautiful; and unless they are beautiful, our delicacy of feeling and power to appreciate nature, which is full of beauties, will be impaired. A hock-bottle is a mere elongated bubble, with the bottom portion pressed in so that it may stand, and the neck thickened by a rim of glass being placed around it.

Here we have a bottle shaped by natural agency; it is formed of heavy glass, and the bubble was thick at its lower part, hence its elongated form; but if length is required in any bubble, and the glass is even light, it can always be given by swinging the bubble round from a centre, so that centrifugal force may be brought into play in the direction of its length; or if it has to be widened, this can as easily be done by giving to it a rotatory motion, whereby the centrifugal force is caused to act from the axis of the vessel outwards, and not from the apex to the base, as in the former instance. In either case a certain amount of beauty would appear in the shape produced, for Nature here works for us.

Our wine-bottles are moulded, hence their ugliness. We work without Nature's assistance, and we reap ugliness as the reward. Let us now consider what a decanter should be. In many respects, the wants which a decanter is intended to meet are similar to those which are met by the bottle, as just enumerated, but here is a great difference—a bottle is only *intended* to be filled once, whereas a decanter is intended to be filled many times; and a bottle is made so that it can travel, while a decanter is not intended to be the subject of long journeys. It is true that a bottle may be re-filled many times, but it is not intended that it should, as the fact that we use a funnel when we wish to fill it clearly shows, and without a funnel the vessel is not complete. All objects when intended to be re-filled many times should have a funnel-shaped mouth (see my remarks on the Greek water-vessel, Vol. II., page 376), but if a bottle had a distended orifice it would not be well adapted for transport. A decanter should have capacity for containing liquid; it should stand securely, and should have a double funnel—a funnel to collect the fluid and conduct it into the bottle, and a funnel to collect it and conduct it out of the bottle. It must also be convenient to use and hold, and the upper funnel should be of such a character that it will guide the liquid in a proper direction when poured from the decanter.

If we take a flask and flatten its base, and extend the upper portion of the neck slightly into the form of a funnel, we have all that is required of a decanter, with the exception of a permanent cork, which is a stopper (Fig. 94).

But as most decanters are intended to hold wine, the brilliancy of which is not readily apparent when that portion of the vessel which contains the liquid rests immediately upon the table, it is desirable to give to the vessel a foot, or, in other words, raise the body of the decanter so that light may surround it as fully as possible (Figs. 95 and 96).

In Figs. 97 to 108* I give a number of shapes of decanters and jugs, such as may be seen in our best shop-windows, and such as I consider desirable forms for such vessels; and in considering the shape of such vessels, the character of the upper portion of the neck must be regarded, as well as that of the body and base.

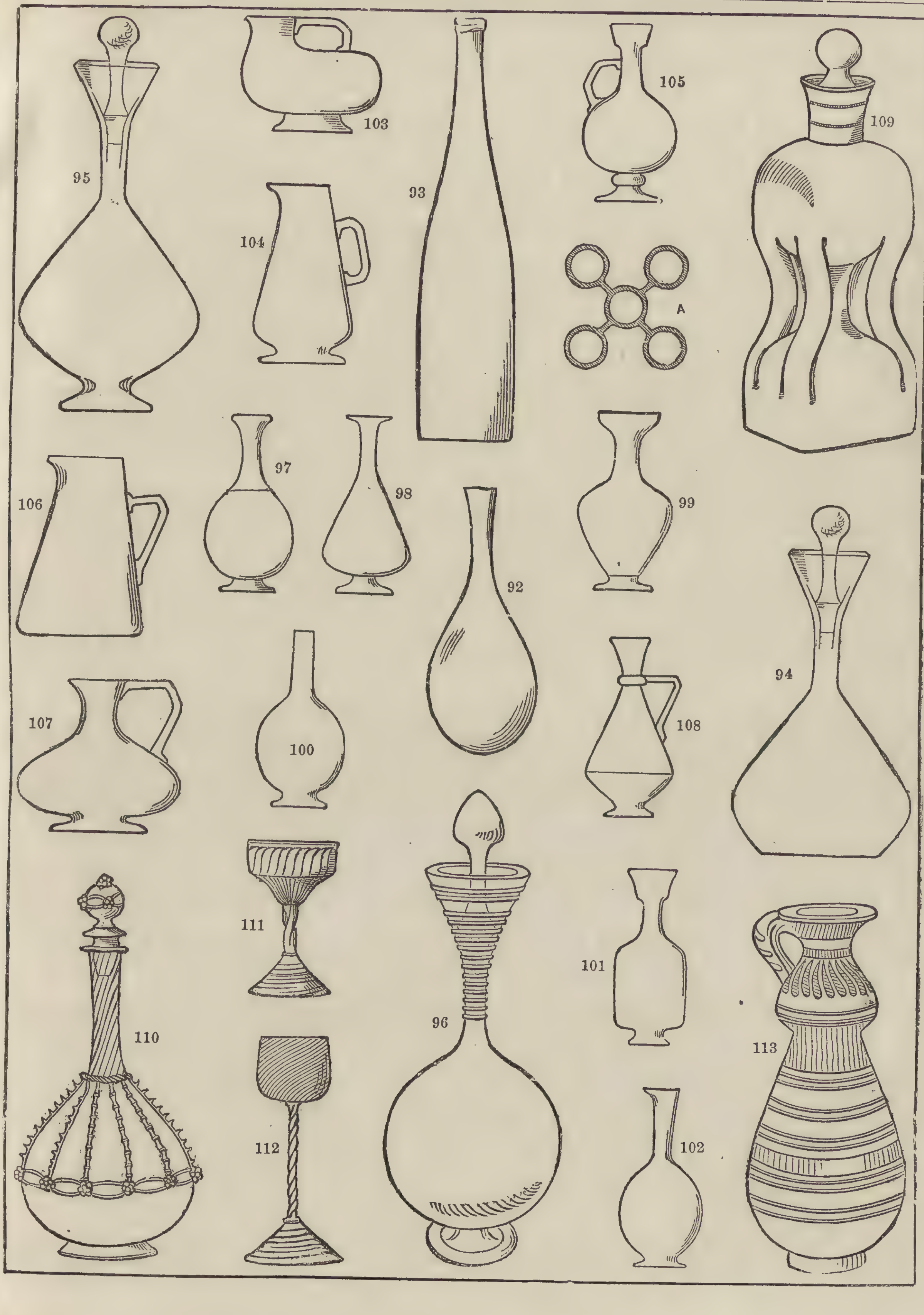
Besides decanters and bottles, glass is formed into tumblers, wine-glasses, flower-holders, and many other things; but the principles which we have already laid down will apply equally to all, for if the objects formed result from the easiest mode of working the material, and are such as perfectly answer the end proposed by their formation, and are beautiful, nothing more can be expected of them.

Many objects of fancy shape have been produced as mere feats of glass-blowing, and with some of the efforts I sympathise. Wherever the work produced is truly adapted to use, or where an artistic effect is achieved, the glass-blower has my warm sympathy, but if the effort is made at the production of novelty merely, the result gained is sure to be unsatisfactory. Much of the Venetian glass will illustrate these last remarks.

Fig. 109 is a very excellent and picturesque spirit bottle; it is easy to hold, and quaint in appearance.† Figs. 110, 111, and 112 are Venetian glass vessels, wrought entirely at the

* Respecting the application of handles to vessels I will speak when noticing silversmiths' work.

† In order that the nature of this bottle be better understood, I give a section of it at A.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furnace mouth, and neither cut nor engraved—they are artistic, and of interesting appearance; while Fig. 113 is a work of Roman glass, in which the upper distension is useful if the liquid contains a sediment which it is not desirable to pour out with the liquid.

FARMING AND FARMING ECONOMY.—VII.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

FORAGE or green crops are represented principally by a few familiar species, for the most part belonging to the natural orders *Leguminosæ*, *Cruciferæ*, and *Gramineæ*. There are besides these a considerable number of plants grown to a limited extent which demand a passing notice.

LEGUMINOUS FORAGE PLANTS.

The vetch or tare (*Vicia sativa*) includes summer and winter vetches: the first, a quick-growing variety, sown in the spring; the second, hardier, and sown in the autumn. Both are extensively cultivated, and although suitable for all classes of land, prefer those of a calcareous character. Vetch cultivation commences immediately after harvest, and proceeds as follows: If the land is foul, it should be thin-ploughed or pared (*i.e.* cultivated to the depth of about two inches), rolled, and harrowed; the weeds should then be collected, burnt, and the ashes spread; twelve to fifteen single horse-loads of manure carted on to the land, spread, and ploughed in, with a moderately deep furrow. The earliest winter vetches are planted towards the end of August; the second sowing takes place a month or six weeks later, and sometimes a third sowing is effected before winter. It is not advisable to plant this crop later than the 15th of November. The cultivation for spring vetches is similar to the above. The work should have been accomplished in the winter, so that the seed may be sown as soon as a suitable opportunity presents itself in early spring. Consecutive sowings at intervals of a month may be persevered in until the latter end of May. By this system an excellent food for stock is provided from the beginning of May to the end of September, when turnips will be fully ready for use. Vetches are sown by the drill in rows eight inches apart, at the rate of $2\frac{1}{2}$ bushels of seed per acre, to which, in the case of winter vetches, half a bushel of winter oats, rye, or, better still, beans, has been added to support the plants. The after cultivation consists in rolling, and hoeing, if necessary. The crop is consumed on the ground by sheep, or cut for horses and horned stock. For lambs, vetches can scarcely be used too young, but old sheep and horses will thrive better upon them when the pods are filling with seed. They are ready for consumption when just coming into flower.

V. sativa is the only species cultivated in this country.

M. Heuzé and Professor Wilson describe several other species as (1) the white or American vetch, also called the Canadian lentil, with white seeds and violet flowers; (2) the large-podded vetch (*Vesce à gros fruits*) (*V. macrocarpa*); (3) the Hopetown or Scotch vetch with white flowers; (4) the Siberian vetch (*V. biennis*); (5) the tufted vetch (*V. Cracca*); (6) the Russian vetch (*V. villosa*); (7) the yellow-flowered vetch (*V. lutea*); (8) wood vetch (*V. sylvatica*); (9) narrow-leaved vetch (*V. angustifolia*); (10) Narbonne vetch (*V. Narbonensis*); (11) saw-leaved vetch (*V. serratifolia*), to which we may add the Australian vetch lately imported by the Messrs. Carter of London.

Red clover (*Trifolium pratense*) was introduced into this country by Sir Richard Weston, Ambassador to the Low Countries, in 1645. This plant thrives upon a large variety of soils, but best upon calcareous clays and loams. It is universally cultivated alone, and as an ingredient of mixtures for pasture. It usually follows a corn crop after fallow or roots, and occupies the ground profitably for one year. It is sown upon young barley or wheat in April with the drill or the broadcast barrow, the former plan being the best, at the rate of 20 lb. per acre. The land should be Cambridge-rolled previously to sowing, and subsequently brush or chain harrowed.

Red clover is liable to clover sickness, *i.e.* to fail upon land which has frequently grown it. The reason of this is obscure, but probably it is a deficient supply of plant-food. Applications of lime, liberal management, and intervals of eight years between crops of red clover, are the best means for ensuring success. The young plants may be lightly stocked with sheep in the autumn, but all stock should be removed before frosty weather sets in. The crop may be mown or fed, and will yield about 10 tons of green food, or $2\frac{1}{2}$ tons of excellent hay.

Crimson or scarlet clover (*Trifolium incarnatum*) is an annual differing widely from the last species. The "flowers" of red clover are purple, globular, and sessile; while those of *incarnatum* are crimson, elongated, and supported on a stalk. There are two cultivated varieties, the first scarlet, the second a light pink or French white. Crimson clover was introduced into France in 1791 by Prince Pré de Buire, and into Berwickshire in 1821 by Sir John Sinclair. It is usually sown in the autumn upon corn stubbles. The only cultivation necessary is to harrow the surface, sow the seed broadcast at the rate of 14 lb. per acre, and to roll or harrow it in. The crop is cut in May, and the land is then broken up for roots. This method of cultivation is suitable for free working and clean land only.

White Dutch clover (*T. repens*) is useful in two-year old pastures when the red clover has in a great measure died out. It is never sown alone.

Alsike or Swedish clover (*T. hybridum*) was originally brought from Sweden by Mr. George Stephens of Edinburgh. The seed thus introduced was planted by the Messrs. Lawson in Meadowbank Nursery, April 17, 1834. This plant grows vigorously, and is an important ingredient in mixtures for one, two, or three years' pasture. It is suitable for moist, cold soils, and has been exceedingly luxuriant during the past cold summer. It has white and pink flowers and a vigorous habit of growth. The seed is very small, and a comparatively small quantity per acre, generally about 2 lb., mixed with others, is sufficient.

Zigzag clover (*T. medium*); hop trefoil (*T. procumbens*); suckling clover (*T. filiforme*); Egyptian clover (*T. Alexandrinum*); Alpine red clover (*T. alpestre*), and *T. elegans*, a plant closely resembling Alsike clover, are among other cultivated species of this family, but the above four species are the only ones widely cultivated in Britain.

Trefoil, "Nonsuch," black medick, or yellow clover (*Medicago lupulina*), is a general favourite with farmers, and is either sown alone or mixed with other clovers and grasses. It usually follows barley and precedes wheat, and is sown upon the young corn in March or April at the rate of 18 lb. per acre. It is especially suitable for dry, chalky soils, and affords early sheep keep the succeeding spring. Lucerne (*Medicago lupulina*) was well known to the ancients, and is extensively cultivated in all southern countries. It was introduced into England in the seventeenth century, and into Lothian by the Earl of Haddington, and Mr. Cockburn of Ormiston, between the years 1720 and 1730 (Wilson). It succeeds best upon dry calcareous soils, and improves in productiveness for three years after sowing, and may be profitably left in possession of the ground for from eight to ten years. It is sown upon clean, well-cultivated land in March, at the rate of 10 lb. per acre, in rows fifteen to eighteen inches apart, and the after cultivation consists in keeping the land clean by hoeing.

M. maculata, spotted medick or hedge-hog plant, and *M. falcata*, yellow lucerne, are used occasionally as forage crops, although seldom or never seen in the agriculture of this country.

Closely allied to the above trifoliate plants are the Melilots, *officinalis* and *leucantha*, and the bird's-foot trefoil (*Lotus corniculatus*), used in mixtures for permanent pastures.

Sainfoin (*Onobrychis sativa*) and its variety *bifera* are also importations from the Continent of Europe. Heuzé informs us that sainfoin was introduced into England in 1651, but does not say by whom. In the south-west of England, and especially on the Cotswold hills, it is a favourite crop, and in other parts of this country it forms an ingredient in mixtures for two or three years' pasture. It affects dry limestone soils, and resists long continued drought successfully. On the Cotswolds it is drilled across the young barley at the rate of $3\frac{1}{2}$ to 4 bushels of unmilled, or 50 to 60 lb. of milled seed per acre, the former being preferred. A small quantity of trefoil should be mixed with the sainfoin seed to assist in occupying the ground the first year, when the sainfoin is somewhat feeble. Young sainfoin should be mown the first year, as grazing tends to check its development. After the first season it is stocked with sheep, and it remains in possession of the ground for six or seven years.

Gorse (*Ulex Europæus*), known also as furze and whin, is cultivated with advantage upon poor land. It is sown in March or April at the rate of 35 to 40 lb. of seed per acre, in

rows ten inches apart, upon properly prepared ground. The crop is ready the second autumn after sowing, and is cut with a heavy hook, tied into bundles of about 20 lb. each, and stored. 2,000 such bundles, or about eighteen tons per acre, is considered a good crop. The gorse requires to be broken in a Walsh's bruiser, or upon a block by a mallet, before it is given to stock, and when so treated cattle and horses relish it.

Kidney vetch (*Anthyllis vulneraria*) may be used on dry sandy soils. It does not give a large yield, but is greedily eaten both by horses and cattle, and stands alike great heat and drought (Lawson and Sons).

CRUCIFEROUS FORAGE CROPS.

Rape (*Brassica campestris olifer*), the colza of the Continent, is widely cultivated. It is also called "smooth-leaved summer rape," to distinguish it from "rough-leaved winter rape" (*Brassica Napus*). Of these two species, the first has smooth, fleshy, glaucous-tinted leaves, while the second has rougher leaves of a vivid green colour. This description of the leaf refers to the mature plant. The author has never seen the latter species cultivated in this country, but the former, also known as coleseed, is familiar to every farmer. This plant is probably a cultivated variety of the swede in which the development of the bulb has been sacrificed for the production of leaves and seeds. It is suitable for any sort of land, but succeeds best upon peaty soils, as in Lincolnshire, where it produces a surprising amount of sheep-food. It is also a favourite in all sheep districts, where it is looked upon as a good introduction to turnips and winter food. It also enables the farmer of clay land to maintain sheep stock in the summer, although, from the nature of his land, debarred from extensive root cultivation. This crop may be sown early in May for consumption in July, and all through June, July, and August. It is occasionally sown in seed-beds, and transplanted on to prepared stubbles in September, when it will yield a useful crop in early spring. The cultivation is precisely the same as for turnips. Rape should be sown with the drill at the rate of 4 to 5 lb. of seed per acre, in rows about eighteen inches apart, and when the plants are sufficiently advanced (see Turnip Cultivation, Vol. II., p. 373) they should be singled, or at least thinned in the rows, leaving two or three plants together every eight or ten inches. The crop should be horse-hoed about a month after sowing, and should be harrowed several times. This treatment is said to greatly stimulate the growth of the plants. They are ready for use three months after sowing, and a maximum crop will maintain 400 sheep per acre for one week, and may be worth from £3 to £4. Rape is generally eaten by sheep upon the land.

White mustard (*Sinapis alba*) is of comparatively recent introduction as a forage crop. It is much used when from drought or other causes there is a deficiency of winter food. Under such circumstances, as in 1868 and 1870, every endeavour is made to economise turnips in the autumn, and no sooner are the stubbles cleared than they are cultivated or ploughed, and sown with mustard, rape, or even late turnips. Mustard is singularly rapid in its growth, and under favourable conditions will be ready for folding six or seven weeks after sowing. One peck per acre is a sufficient seeding, and almost any description of soil will produce a crop. Mustard will not stand frosts, and must therefore be eaten before winter.

GRAMINACEOUS FORAGE CROPS.

Winter rye (*Secale cereale*) affords the earliest spring food after turnip "greens." It occupies a portion of the land intended for roots, and is followed by swedes or turnips. The cultivation for rye is the same as for vetches. The seed should be drilled at the rate of 3½ bushels per acre, and seven inches apart about the middle of September. It will be ready for folding in April, and while young it affords a wholesome but rather laxative food for sheep. It should be consumed before it shoots into ear, and dry food and mangel-wurzel are recommended to be eaten with it. St. John's day rye is a variety of the above which comes to maturity a fortnight later. Winter barley and winter oats may also be used as forage crops, and will give a continuation of food after the rye is finished.

Italian rye-grass (*Lolium Italicum*) was first brought to this country by Mr. Thomson of Banchory, who obtained some seed at the agricultural show at Munich, about the year 1830. This was grown by the Messrs. Lawson, who subsequently introduced it to the agricultural public. Italian rye-grass far surpasses the English species (*L. perenne*) in luxuriance, and is at once distinguished from it by its broader and more upright leaf, and by its awned seeds. It has been used for purposes of sewage irrigation, and is better adapted for liquid manuring than any other crop. Fifty to seventy tons per acre of grass have in this way been obtained in a single season. In ordinary agriculture it is either sown upon young barley in the same manner as "seeds" (see Rotations, Vol. II., p. 261), or the land is specially prepared by ploughing in manure upon a corn stubble in the winter, cross cultivating in the spring, harrowing, and sowing four bushels of seed per acre with the broadcast barrow, after which the land is rolled or lightly harrowed. Ten tons of grass have been cut six weeks after sowing, but such a result must be looked upon as exceptional. Rye-grass affords several cuttings in the season, and a dressing of nitrate of soda, guano, or liquid manure between each cutting will be repaid by a largely increased yield.

Schræder's brome grass (*Bromus Schrœderi*), although previously known in England, has of late years been brought prominently before the notice of farmers, as likely to supersede Italian rye-grass; but although giving a large bulk of forage, its cultivation does not increase, as its produce is neither so early nor so fine—such, at least, is the opinion of the Messrs. Lawson.

The agricultural grasses include about fifty species. Even a few words upon each of them would extend the limits of the present paper beyond all bounds. In order to at once convey an idea as to the species most usually employed, and the proportions in which they are blended so as to form mixtures, we introduce a table from Messrs. Carter's catalogue, in which suitable mixtures are given for medium soils of alluvial origin, calcareous character and loamy character:—

Mixture of Permanent Pasture Grasses for Medium Soils.	Alluvial Soils.		Limestone or Calcareous Soils.		Loams Derived from Old or New Red Sandstone.	
	With a Crop.	Without a Crop.	With a Crop.	Without a Crop.	With a Crop.	Without a Crop.
	lb.	lb.	lb.	lb.	lb.	lb.
Anthoxanthum odoratum (*Sweet Vernal*)	1	1	1	1	1	1
Alopecurus pratensis (*Meadow Foxtail*)	3	3	2	2½	2	2
Arrhenatherum avenaceum (*Large Oat Grass*)	...	...	2	2½	...	...
Trisetum flavescens (*Golden Bristle Grass*)	...	...	2	2	...	...
Dactylis glomerata (*Cocksfoot*)	4	4½	3	3	4	4½
Festuca duriuscula (*Hard Fescue*)	2	2	2	2	2	2
—— heterophylla ovina (*Sheep's Fescue*)	1½	2	2½	3	2	2
—— loliacea (*Darnel-leaved Fescue*)	1	1	1	1	1	1
—— pratense (*Meadow Fescue*)	2	2	...	...	1	1
Lolium Italicum (*Best Imported Italian Rye Grass*)	8	9	6	8	8	9
—— perenne (*Pacey's Perennial Rye Grass*)	4	5	6	7	3	4
Phleum pratense (*Timothy*)	4	4½	2	2½	3	3½
Poa nemoralis (*Wood Meadow Grass*)	1	1	2	2	1	1
—— trivialis (*Rough-stalked Meadow Gr.*)	1	1	2	2	...	...
Trifolium pratense perenne (*Perennial Red Clover*)	5	6	5	5	5	4
—— repens (*Perennial White Clover*)	3	3	4	4	3	4
—— hybridum (*Alsike Clover*)	1	1	...	...	1	1
Medicago lupulina (*Yellow Trefoil Clover*)	3	2	3	3	3	3
	44½	48	45½	48½	40	44
Per Imperial Acre (best quality)	31s.	32s.	31s.	32s.	30s.	31s.
Second quality	20s. to 26s. per acre.					

In sowing grass seeds for permanent pasture care must be taken to have the land in good condition, and clean—*i.e.*, free from weeds. They are most generally sown upon young barley or wheat, in April or early May. The surface must be rolled smooth, and the seeds will be best distributed with a seed barrow, and brush-harrowed in.

Mixtures for one, two, or three years are much simpler, and are formed as follows:—

	For 1 Year's Hay and Pasture.		For 1 Year's Hay and 1 Year's Pasture	For 1 Year's Hay and 2 Years' Pasture
	No. 1. lb.	No. 2. lb.	lb.	lb.
Trifolum pratense	14	8	6	4
T. repens	...	2	4	4
T. hybridum	2	2	2	3
Medicago lupulina	...	4	4	4
Lolium Italicum	18	18	9	9
—— perenne	9	9	18	18
Phleum pratense	...	2	2	2
Dactylis glomerata	2	2	2	2

Such mixtures may be varied to suit the peculiarities of soil and climate to an indefinite extent. Pastures for alternate husbandry are sown as in the case of permanent pasture.

Among other plants which are grown to a limited extent, or have been recommended to the notice of farmers, are the following:—Broom (*Cytisus scoparius*), very rarely used as an addition to sheep pastures; buckwheat (*Polygonum fagopyrum*), principally used for pheasant feeding; burnet (*Poterium sanguisorba*), sown to some extent on high chalky lands instead of clover. Chicory (*Cichorium intybus*) might be more extensively grown with advantage. Comfrey (*Symphytum officinale*) and prickly comfrey (*S. asperrimum*) have recently received attention as available plants for forage. Spurry (*Spergula arvensis*) is used on the Continent as a winter food for sheep, and is sown for this purpose on the stubbles. Yarrow or Mill-foil (*Achillea millifolium*) is a good addition to mixture of pastures. Plantain (*Plantago lanceolata*) is similarly used, as is also field parsley (*Petroselinum sativum*). White lupins (*Lupinus albus*) are occasionally sown on light sandy soils for forage, and for ploughing in as green manure. Chinese sugar-cane (*Holcus saccharatus*) is cultivated a good deal in the south of France, and to a very limited extent in parts of the south of England. Numerous other plants have been suggested by sanguine agriculturists and enterprising seedsmen, but restricted space compels us to desist from further lengthening our list with names which exert so small an interest on the agriculture of our country.

SHIP-BUILDING.—III.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

ELEMENTARY REMARKS ON THE STRENGTH AND STRAINS OF SHIPS (*continued*).

NEXT in importance to longitudinal strains are those tending to cause alterations in the transverse forms of ships, and some attention must be given to them in order to understand their causes and possible effects.

The transverse strains experienced by a ship floating in still water are not usually severe, and only become noteworthy when very heavy weights are concentrated upon, or near, the sides of the vessel. In an iron-clad ship, for example, the weight of the armour-plates secured to the sides is very great; and if we consider, say, the middle portion of the length, where the ship's breadth is nearly at its maximum, it will be evident that there exists a condition of strain similar to that shown in Fig. 2 (Vol. II., p. 401). The whole weight (w) of one side of the ship will act downwards in a line (indicated by the arrow) further away from the centre of the ship than the line of action of the total buoyancy (w) of that side, supposing for the sake of simplicity the weight to equal the buoyancy. Consequently a "couple" is brought into action on each side of the ship, and its tendency is obviously to cause a change of form in the cross-section. Even in the most extreme cases, however, this bending moment cannot be of very large amount when the vessel is afloat; but supposing her to take the ground, and to be supported on her keel only, it would be very much increased, for the line of action of the upward pressure would then be removed to the middle line of the ship, and be much more distant from the line of action of the weight w.

In addition to these vertical forces tending to changes in the transverse form, it is necessary to consider the horizontal forces, due to the pressure of the water on the sides of a ship afloat. The direct tendency of this pressure on each side is obviously to bring the two sides of the vessel more closely together, thus producing a change in form, which must be resisted by the transverse strength of the hull. For a ship floating upright, or in an inclined position, in still water this pressure and its bending effect can be found without much difficulty.

These are merely statical strains, the ship in each case being supposed at rest, and consequently they cannot be compared in intensity with the dynamical strains incidental to rolling motions when the ship is at sea. Under these circumstances it is by no means unusual to find ships, particularly wood ships, actually undergoing changes of transverse form, and in many cases the "working" of the various parts has caused serious damage. Nor is this to be wondered at, considering that the vessel would move rapidly from side to side, passing several times per minute, it may be, from a position like that indicated in Fig. 3 (page 401) to one of as great inclination on the opposite side, and necessarily having her motion checked and reversed rapidly. Here again we meet with a case which foils accurate calculation of the intensity of the straining forces, and permits only of approximate estimates being made. Here also experience comes to the aid of the ship-builder, who has a knowledge of the accidents that have befallen ill-constructed vessels, and is thus enabled to provide sufficient strength in the parts most tried.

For our present purpose it will suffice to say that in resisting these strains the transverse sections of ships (such as are illustrated by Figs. 2 and 3) must act more or less like hoop-shaped girders. The most critical parts in such sections are obviously at the junctions of the beams and the frames (*a*, *a* and *b*, *b*, in Fig. 3), and near the turn of the bilges (*c*, *c*); and observation confirms the necessity for providing special strength thereat. The maintenance of transverse form is also much aided by efficient pillars being fitted in the hold and between the decks. Transverse bulkheads also help considerably to this end, especially in iron and composite ships, where their numbers are often so considerable as to practically prevent change of form in the transverse sense.

Supposing provision to have been made for both of these principal strains—the longitudinal and the transverse—there still remains the consideration of *local* strains and the means of meeting them. Having already said something on this point, only a few remarks need be added in illustration of its importance. In many places weights are concentrated in short lengths of the ship, especially if she be a steamer: to support such weights, and to distribute the load over portions of the hull not directly beneath, or "in wake" of them, "bearers" must be fitted. Where the masts are to be supported "steps" have to be built, to bear and to distribute the downward "thrust." The deck-beams also must be made capable of bearing the weights to be put upon them; the requisite strength of bottom for taking the ground should be provided; and in many other instances the ship-builder has to exercise similar caution. In short, this part of the work is of considerable importance, although subordinate to the main features of the construction, and as it is left more completely in the hands of the ship-builder, it demands the greater attention from him, in order to make special and indispensable arrangements contribute as much as possible to the structural strength.

To a very large extent this is also true of the minor details of the construction, and as a case in point we may refer to the bulkheads or partitions built in the holds of ships to subdivide the space according to the requirements for accommodation and stowage. It is possible, and in well-built ships is actually the case, to add considerably to the vessel's strength without using a much greater weight of material, by turning such partitions into more or less rigid girders, especially when they run longitudinally, as many of them do. For example, in steam-ships there are often coal-bunkers at the sides, the interior boundaries of which are formed of thin iron plating, which must be stiffened to some extent in order to bear the weight of the coal: by the simplest arrangement possible these iron bulkheads can be converted into valuable stiffeners to the structure of the ship at a part where considerable strength is required. It is needless to multiply illustrations, but we must add that in iron ships this principle of utilising the partitions, etc. (fitted necessarily and primarily for stowing the hold), as a means of gaining structural

strength, can be best applied; and there can be no doubt that at the present time there is considerable scope for improvement in this direction.

THE COMPARATIVE FITNESS OF WOOD AND IRON FOR SHIP-BUILDING.

Closely allied to the subjects we have just been considering, stands the question of the suitability of the materials commonly used by the ship-builder, and the facilities which they afford for carrying out in practice the principles of construction that have been sketched. Until fifty years ago there would, as we have said, have been question of one material only, wood; but now iron occupies the first place, and the following remarks will probably throw some light upon the causes of its rapid replacement of wood. It is not our intention here to describe the various kinds of timber used in wood ships, or to distinguish between different qualities of iron; but rather to take for granted that in both classes of ships the best materials procurable are employed, and then to examine their relative advantages from a structural point of view.

A merely casual glance might lead one to believe that because iron is *stronger* than wood, it is also superior for ship-building; but this is by no means a complete view of the question. The ship-builder has to consider not only the strength, but also the weight of the material he uses; and it is a matter of fact that, *weight for weight*, a solid bar or beam of wood of rectangular section is in some respects stronger than a similar bar of iron. The latter would bear, say, a tensile strain of 20 or 22 tons to the square inch of sectional area, while the wood would only bear 5 or 6 tons; but on the other hand the iron would weigh, say, 480 lb. to the cubic foot, while the wood would only weigh about 60 or 65 lb. This merely superficial view of the matter, therefore, will not do.

Looking more closely into the characteristics of wood and iron, one sees that there is a fundamental difference between the two materials. The wood is necessarily used in massive solid timbers, the sectional forms of which are more or less nearly rectangular; whereas the iron can be procured with an almost endless variety of sectional forms, and is but rarely used in masses having great thickness as well as breadth. No simpler illustration of our meaning could well be given than that in Fig. 5, where three sections of beams are shown, two of iron, and one of wood (marked 3). The wood beam is of rectangular sectional form, and almost necessarily so; but the iron beams are "flanged" in just the way that science teaches to be the best possible form for resisting bending strains. The upper and lower parts of a bent beam are necessarily subject to the greatest strains, while the parts lying between them are comparatively unstrained. Consequently the best form of section is that which throws a large amount of material into "flanges" at the upper and lower parts, leaving a thin web between, as is done in the iron beams. No practical shipwright would for a moment dream of imitating this sectional form in wood beams, because the very nature of the material forbids the attempt, and it could only lead to failure. Hence we see that the first principle of construction—viz., to dispose the material so that its amount shall be every-

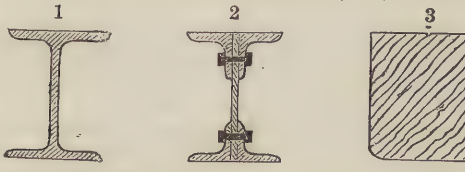

Fig. 5.—SECTIONS OF BEAMS. 1, 2, Iron; 3, Wood.

where proportioned to the strain it has to bear—can be much more nearly fulfilled in iron beams than in wood.

What has been shown to be true in this simple case is true also in very many other parts of a ship's structure; for instance, in the ribs, which are formed in an iron vessel of comparatively light angle-irons, while in a wood vessel they consist of massive timbers. The grand result of this difference is that in using wood the builder is frequently compelled to place a large weight of material in parts where it is not needed, because he is restricted to the *solid* sectional form; whereas the iron can be either rolled to whatever sectional forms may appear desirable, or easily combined in such a fashion as to arrive at these forms. Before Cort's great invention of *rolling* was introduced no such facilities were available, and even plates of wrought iron were only procured with difficulty by hammering them out; but when once this idea had taken a practical shape, and the path was marked out, progress became rapid. The strides made in this country in the manufacture of iron during the last twenty years have been particularly noteworthy, and even in the last ten years advances have been made which probably surpass all that had been done previously. Armour plates 18 or 20 inches thick, weighing many tons, are now produced, and the skill thus manifested is applied in other directions with no less profit. Let us not forget, however, that all this progress has been rendered possible by an invention of the simplest character, made by a

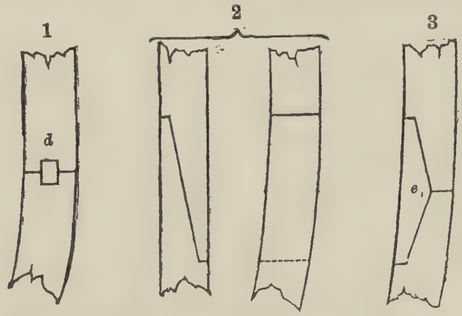

Fig. 6.—MODES OF CONNECTING TIMBERS OF FRAMES.

man without pretensions to great scientific acquirements. Cort reaped no great reward, it is true, but he conferred a lasting benefit of immense value upon his country and the world at large, and his name should be held in honour.

Passing on, we will next compare the *connections* of the various parts that can be made in wood and in iron ships, a subject of considerable importance; and here one cannot fail to remark the wonderful contrast between the capabilities of the two materials. It has been pointed out that the various longitudinal pieces in the hull of the ship ought to be capable of resisting both tensile and compressive strains, and this fact must be borne in mind here, seeing that it applies with more or less force to transverse framing also. In Figs. 6, 7, and 8 are represented a few of the principal methods of connecting adjacent pieces in the hull of a wood ship, and it will at once appear that no small amount of care and good workmanship are required to carry some of them into practice. The chief difficulty to be overcome in such connections is obviously to make the joint capable of bearing a *tensile* strain, for a plain "butt"—where the ends of the adjacent pieces are cut off square and fitted together—will answer every purpose under a compressive strain, since that tends simply to make the joint closer.

Taking the sketches in order, we first have three modes of connecting the timbers of frames in wood ships. That marked 1 shows what is termed a "plain butt" joint, the only connection between the timbers being formed by the dowel *d*, which is a cylindrical plug of hard wood driven tightly into holes cut out of the ends of the timbers. This connection obviously has little or no strength to resist strains tending to "open" the butt and separate the timbers; but in fairness it should be noticed that the transverse frames are not as a rule liable to severe strains having such a tendency. The plan marked 2 shows two views of a "plain" or "plane" scarf, and needs no explanation beyond the statement that the overlapping timber-ends are usually secured together by dowels in the bearing surfaces as well as by through-bolts. This plan is evidently possessed of considerable power for resisting tensile strains, and it is used in the few parts of the framing where those strains may be expected to be considerable—for instance, in the neighbourhood of the masts, where the shrouds are secured to the upper works of the ship. The plan marked 3 is now used only in building merchant ships (instead of 1); *e* is a "chock" of wood fitted into recesses cut in the timber-ends, and is secured to both by bolts or "tree-nails" (*i.e.* long wooden pegs), thus forming a sort of strap over the butt, and giving some power of resistance to tensile strains. In fact, in the olden times of wood ship-building the mode of connection illustrated by 3 was, in principle, a very common one for securing pieces subject to considerable tensile strains, only the

chocks were made much longer, in order to distribute the fastenings over a larger area and give greater strength. We should add that the plain scarf (2) is still very largely employed in connecting pieces running longitudinally in wood ships: for example, the keelson, and the shelf-pieces underneath the ends of the deck-beams.

The remaining examples of the connections used in wood ships are of a more elaborate character, and are used only in parts where the greatest possible amount of resistance to tensile strains is required. The "scarf with tabling" in Fig. 7 is shown in elevation, plan, and section, and will be seen to constitute a strong connection; but it evidently necessitates great care and expense for workmanship. This scarf is, in fact, a plain scarf, plus the "tabling" (marked *t* in the sketch); the latter consisting of raised tenons fitting into corresponding mortises, as is clearly shown by the section at *a*, *a*. For one-half the length of the scarf the tenon is formed on one of the pieces, and

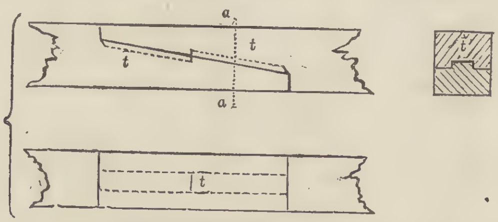

Fig. 7.—SCARF WITH TABLING.

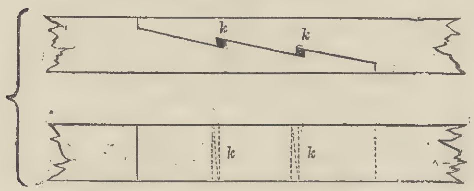

Fig. 8.—HOOK SCARF WITH KEYS.

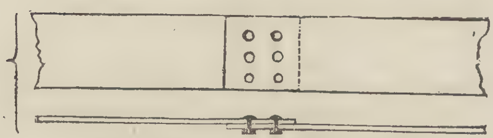

Fig. 9.—IRON PLATES WITH LAP JOINT.

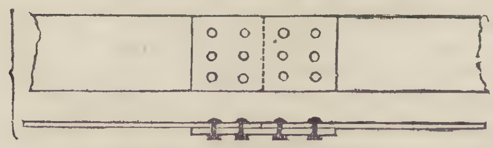

Fig. 10.—IRON PLATES WITH FLUSH JOINT.

for the other half on the other; the mortises being situated, of course, conversely in order to receive them. It will be noticed that the tenon is formed on the thinner half of the scarf in each piece, and that its breadth is about one-third that of the pieces joined. This kind of scarf is used for the keels of wood ships, and being fastened by numerous bolts (six or eight in a large ship), it forms a very strong connection.

No less elaborate is the "hook-scarf with keys" shown beneath it, a connection which is commonly used in putting together the pieces of the beams in wood ships. When formed and fitted, wedge-shaped iron keys (marked *k*, *k*) are driven into spaces left for this purpose at the shoulders of the "hooked" surfaces, and the scarf is thus tightened or "set up." In this case also the scarf is fastened by means of several through-bolts and tree-nails, which have been omitted in the sketch for the sake of clearness.

On a review of all these examples of the most approved connections used in wood ships, it becomes obvious that great difficulty has been experienced in rendering them efficient, and that a fair resistance to tensile strains can only be secured by elaborate and expensive joints. Turning to iron ships, an entirely opposite state of things is found; for in them the most simple and inexpensive connections can be made efficient against tensile as well as compressive strains. Two illustrations of this are given in Figs. 9, 10; the first showing a joint where the plates are "lapped" at the ends and riveted, and the second a joint where the plates are "butted," and connected by means of a "butt-strap." One of these two simple plans is applied in almost every case where adjacent pieces have to be joined in an iron ship; the only exceptions being those where thick bars, such as are often used for keels in iron merchant ships, are connected by means of plain scarfs fastened by through-rivets.

Moreover, *welding* can be used to a considerable extent in connecting the parts of iron ships, if it is considered desirable; and those parts themselves can be procured in sizes and bent to forms such as render fewer joints necessary than are required in wood ships. For example, one "rib" or frame in a wood ship of any size is always made up of several pieces connected together in one or other of the modes shown in Figs. 5, 6, and 7; and it is impossible to follow any other course, seeing that timbers of the sizes and curvatures required for the frames cannot be procured in great lengths. On the other hand, it is a very common thing to find the angle-irons forming the frames of iron ships made in one length from keel to gunwale, and any amount of curvature required can be given them. Or to take another illustration: instead of having the beams of a large vessel made up of two or three pieces connected by hooked scarfs, as is the case in wood ships, it is the common practice in iron ships either to have the beams rolled in one length, or else formed of pieces welded or riveted together, the former plan being that which finds most favour now that the facilities for manufacturing iron of the sections required are so greatly increased.

MINING AND QUARRYING.—XIV.

BY GEORGE GLADSTONE, F.C.S.

STEEL (*continued*).

SPIEGELEISEN — BESSEMER STEEL — HEATON'S PROCESS — MECHANICAL PROPERTIES OF STEEL—ECONOMICAL USES —INCREASE OF MAKE.

MORE than once in the preceding papers on iron and steel has the advantage of using manganese been touched upon; but this part of the subject would be incomplete were we to omit referring more particularly to *spiegeleisen*, which is a peculiar description of pig iron made largely in Germany, and bearing a German name which translated into English means "specular iron." It is made from the spathose carbonates which are common in that country, and is highly crystalline, showing large bright cleavage planes, which have given rise to its distinctive name. In chemical composition it is very different from any of the English pig irons which have been previously spoken of, the following being the actual analysis of an ordinary sample:—

Iron	88·961	Nitrogen	1·200
Carbon	5·449	Copper	0·166
Manganese	4·003	Tin	0·116
Silicon	0·179		

Here, then, we have a pig iron rich both in carbon and manganese, and very free from the noxious ingredients which have so constantly followed us in the operations of iron-making. One of the principal reasons for their absence is that the spiegeleisen is smelted with charcoal, and not with coke.

The quantity of manganese, however, varies considerably, and many specimens will give a much larger proportion than that recorded above.

It scarcely needs to be pointed out how convenient it would be to add some spiegeleisen in either of the operations described in the last article for making steel, as it would just supply the ingredients wanted for the purpose, and at the same time, by its freedom from impurities, reduce the relative proportions of those objectionable ingredients in the resulting metal. It is accordingly largely used for such purposes.

An alloy of iron and manganese, called ferro-manganese, is now prepared in Glasgow for the special use of the makers of steel, by reducing, upon the open hearth of a Siemens' furnace, a mixture of the carbonate of manganese and oxide of iron in presence of an excess of carbon by means of a reducing flame. The furnace-bottom is of ground coke, consolidated and baked up

in the form of a large crucible. The charge of the salts of iron and manganese, finely ground and mixed with powdered charcoal or coke, is heated to redness for several hours. It thus becomes converted into a metallic sponge, which contains the reduced metals from both the ingredients, and which is then run down to a solid by raising the temperature to a white heat. The alloy contains from 20 to 30 per cent. of manganese. A German manufacturer has succeeded in making an alloy which contains a very much larger proportion.

We must now turn our attention to what is called the Bessemer process of making steel, in which either crude or refined pig is the article operated upon. The apparatus used is precisely the same as that described under this name in Article XI. for puddling iron, and all that is necessary to produce steel is to stop the operation and pour out the limpid metal into the moulds after about ten minutes' boiling. By that time the carbon will not be so far exhausted as to have converted the metal into a malleable iron. In practice, however, it is difficult to judge with sufficient exactitude when the decarbonisation of the pig iron has gone far enough; and there was always considerable uncertainty as to the quality of the steel produced, so far as the per-centage of carbon is concerned. It has been found more desirable, therefore, to let the operation take its course until the carbon is reduced to a minimum, and then to add a certain quantity of spiegeleisen the analysis of which is known, and from which the per-centage of carbon in the resulting steel can be estimated with sufficient accuracy.

Another process essentially different from Bessemer's, though perhaps partly suggested by his, is that called after its inventor, Mr. Heaton, and which has only recently been introduced. Pig iron is used, which is melted with coke in the ordinary way, in a common cupola furnace; from this it is drawn off into a ladle worked by a crane, and transferred to the converter. This, of which Fig. 3 is a drawing, is a wrought-iron pot, lined with fire-bricks and refractory clay, which runs upon wheels, the chimney from the line A upwards being a fixture supported by the columns, B B. In the bottom, C, of the converter is introduced a charge of crude nitrate of soda, one-tenth in weight of the iron to be operated upon. Immediately upon the soda is laid a perforated iron plate, which is firmly worked into the clay that forms the shoulders, D D. The converter, with its contents, is wheeled under the open mouth of the chimney, and securely fixed in its place; and then the molten iron from the cupola is poured in at the hopper E, the door of which is at once closed.

For the first two minutes all is quiet; then some nitrous flames are seen to escape from the chimney; after the lapse of five or six minutes a violent deflagration occurs, accompanied with a loud roaring noise, and a burst of brilliant yellow flame from the top of the funnel, showing that the reaction is at its height. This lasts for about five minutes, and then suddenly subsides. The whole operation is then complete, the converter is removed, and the contents poured out upon the floor, when cold water is thrown upon the metal to render it brittle. It is then broken up into lumps, and re-heated, forged, and rolled; or the "cake steel," as the broken pieces after being shingled are called, is re-melted in crucibles with the addition of about 3½ per cent. of spiegeleisen, and poured into ingot moulds, which produces a steel of superior quality.

The following analyses, made by Professor Miller, of the pig iron used, the resulting crude steel, and the slag separated, will show that the product is essentially different from what would have been yielded under the Bessemer process; and that Heaton's plan is applicable to irons containing large quantities of sulphur and phosphorus.

	Pig Iron used.	Crude Steel made.
Carbon	2·830	1·800
Silicon with a little titanium	2·950	0·266
Sulphur	0·113	0·018
Phosphorus	1·455	0·298
Arsenic	0·041	0·039
Manganese	0·318	0·090
Calcium	—	0·319
Sodium	—	0·144
Iron (by difference)	92·293	97·026
	100·000	100·000

In comparing the constituent elements it will be seen that a great reduction is made in the carbon, silicon, sulphur, phosphorus, and manganese existing in the pig iron. The analysis of the slag which was separated gave—

Sand	47·3
Silica in combination	6·1
Phosphoric acid	6·8
Sulphuric acid	1·1
Iron (a good deal of it as metal)	12·6
Soda and lime	26·1
	100·0

The presence of calcium in the metal produced was due to the use of lime at the time that Professor Miller made his analysis, but that has since been dispensed with. From the proportion of iron in the slag, it would appear that there is a considerable loss, but it must be borne in mind that 12·6 per cent. in the slag would not amount to more than 3 per cent. in the pig iron used. Under the tests which will be described directly, this steel will compare most favourably with that made by the other processes.

It must be borne in mind that though bearing the same name, and having such a per-centage of carbon in combination with the iron as justifies the use of the term, the steel produced by all these various means is very different from that made in Sheffield by the cementation process. It supplies, however, a want which was becoming increasingly felt, of something that should take an intermediate place between iron and the very expensive steel. As such, its use is rapidly extending; and in order to show how it may be employed to advantage, we must refer to the elaborate series of experiments which have been made by Fairbairn of Manchester on the mechanical properties of steel.

As a civil engineer, his object was to ascertain how far the cheaper kinds of steel especially were suited to the purposes of construction; and for this purpose it was necessary to determine its relative strength as compared with iron, and also whether it could be produced of sufficient uniformity of character to enable the builder to rely upon it. Upon this latter point, a most essential one, his final verdict is, that the homogeneity of its structure can be depended upon; and we may therefore proceed to consider the nature of the tests to which he submitted the metal.

These were threefold. Each of the specimens were submitted to transverse, tensile, and compressive strains; the first of these being by far the most important. The apparatus used for this purpose is shown in Figs. 4 and 5. It consisted of a frame, A, to which were bolted two iron brackets, B B, on which the steel bars to be tested were laid. The space between the brackets was exactly 4½ feet. Immediately over the centre of the bar E, at a point equidistant between the supports, hung the scale D, which could be raised at pleasure from resting on the bar, by means of the wheel and screw C. The weights were placed in the scale, 56 pounds at a time; after each weight was laid on, the deflections were taken, and then the screw C was turned so as to raise the scale and relieve the bar of its load, thus enabling the experimenter to ascertain the effect of the load upon the bar, and to register the permanent set.

The general results arrived at were, that in resistance to a transverse strain the best of this description of steel has nearly 3½ times the strength of a bar of wrought iron of the same dimensions; and comparing, therefore, the relative prices of iron and steel, estimated at £7 and £12 respectively, there would be a saving of 25 per cent. in using the more costly material. The second series of experiments showed that in respect of tenacity the steel was nearly double the strength; which, at the same prices, would also leave a small balance in favour of this metal.

The resistance to compression was found to be equal to about 5½ times that of extension, which suggested the conclusion that the most economical form of a steel bar undergoing transverse strain would be a bar with double flanges, having the area of the bottom flange about double that of the top one. For the sake of comparison, however, a steel girder of the ordinary form was taken, the dimensions of which are shown in the cross-section (Fig. 6); the length between the supports was 13·9 feet. The steel was made on the Bessemer principle at the Barrow hæmatite works. The girder was loaded with 18 tons without breaking, but on adding 2 cwt. more it broke by tension through

the angle-iron of the bottom flange, as shown in Fig. 7. This experiment, therefore, not only corroborated the conclusion previously arrived at as to the best form of a steel girder; but also showed the comparative strength of a steel one of the ordinary form, as a wrought-iron girder of the same dimensions would break on the application of 11 tons 16 cwt.

It will be readily inferred from these data that this description of steel is coming into competition with iron for the ordinary purposes of construction; but there are one or two special applications which deserve notice. The first of these is, as rails.

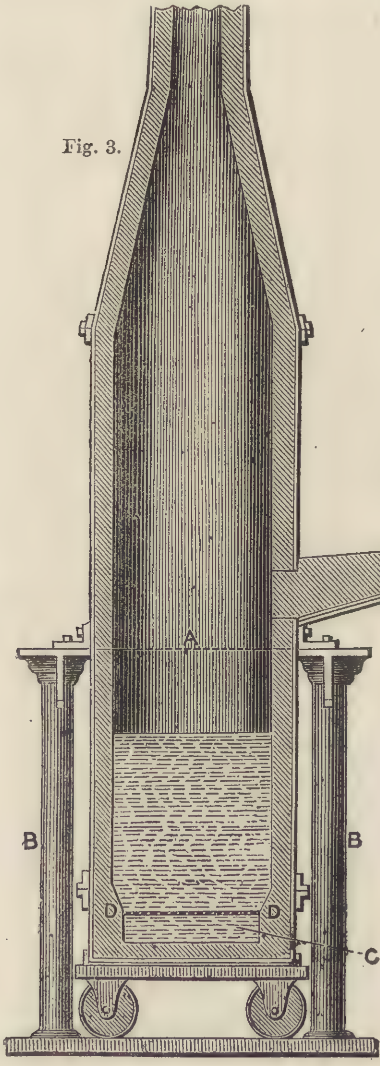

Fig. 3.

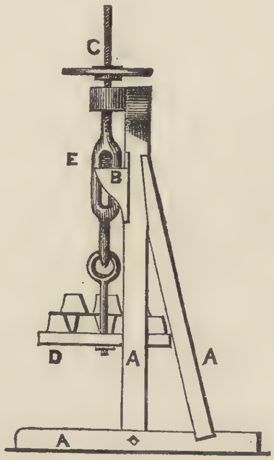

Fig. 5.

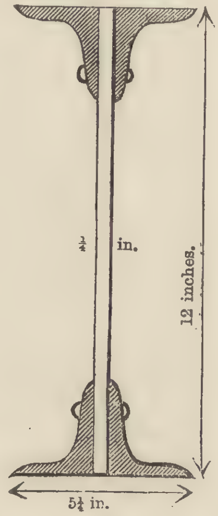

Fig. 6.

Fig. 7.

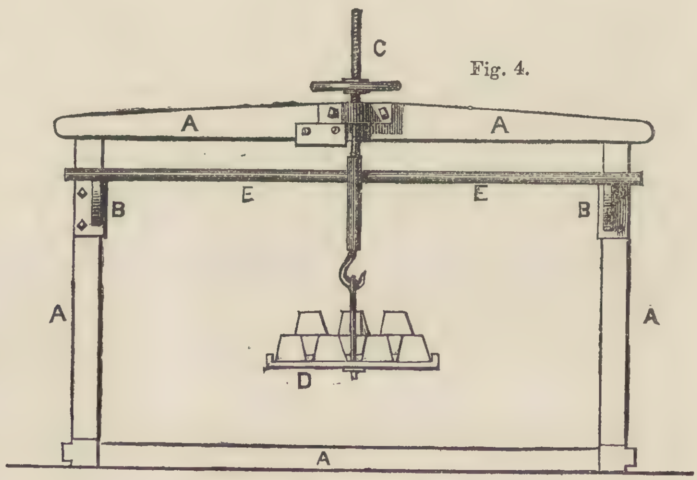

Fig. 4.

Where there is a very large traffic, the wear and tear of the best wrought-iron railway bars is very great, involving the cost, inconvenience, and danger to the workmen, of frequently turning and replacing them. In process of time they split, and large pieces peel off, until they are no longer safe. By making the rails of cast steel, however, the tendency to split is obviated, and the metal is so hard that the wearing by simple abrasion is reduced to a minimum. In those portions especially of a railway where the passing of trains to and fro is very constant, the use of these rails is to be recommended on the score of economy, independently of the other great advantages above named.

Then there is the application of steel to ship-building purposes. Boats made of steel have frequently been taken overland in sections by travellers, and the pieces riveted together in the interior, for the purpose of exploring inland seas, steel being the lightest convenient material which would not be affected by the climate. Its lightness, as compared with iron, is, however, of equal advantage to the general ship-owner, as the displacement of a ship in the water is proportional to her weight; so that according to the number of tons saved in the construction of the vessel, she will be capable of carrying so many more tons of cargo at the same draught of water, and thus earn a larger amount of freight. Besides this there are many rivers and harbours both here and abroad, such as Newhaven and Dieppe, which can only be entered by vessels of light draught, or at certain states of the tide; and into many of these a steel-built vessel could enter at any time, while an iron one of precisely the same size, and built on the same lines, would have to wait outside for the rise of the water. Those only who have experienced the inconvenience of waiting outside a harbour for the rise of the tide, in bad weather, will be able to appreciate this advantage at its full value.

Although, therefore, this manufacture is of comparatively recent introduction, we need not be surprised to find it rapidly growing into favour; that many of the fast steamers round our coasts are already built of steel; and that there are works specially devoted to the manufacture of this article, such as that at Barrow, where 60,000 tons of steel rails, tires, plates, etc., are turned out annually.

FISH CULTURE.—II.

BY GREVILLE FENNELL.

EARLY WRITERS ON FISH CULTURE—FRESH-WATER FISH FARMING—CAUSES OF STERILITY OF FRESH-WATER STREAMS—PROTECTION OF FISHERIES AT HOME AND ABROAD.

MANY works were written during the earlier times in reference to fish culture, for then, during the predominance of the Roman Catholic religion, fish was a necessary article of diet, and every bit of water, natural or artificial, was at a premium, and in consequence made the most of by systematic if not scientific treatment. The Honourable Roger North's work, published in 1713, is notably a great authority on this subject. He descants upon the situation and disposition of the principal waters, of the manner of the making and raising pond-heads, their dimensions, and how to secure their banks; of sluices, of auxiliary waters, stews, moats to lay the great waters dry, of the breeding of fish and stocking waters, of feeding fish, etc. But as this and similar discourses were written at a period when water, as we have said, was extremely coveted, and not as now left to take care of itself, we need not do more than make a passing remark on these authors. Roger North writes, "The string of ponds in Hyde Park are admirably disposed in this respect," which tells us that the Serpentine was not formerly, as now, a continuous sheet of water. He is an advocate for moats, although he thinks they kill more inhabitants than they serve to protect, "the stench and filth from them when laid dry being insupportable." He says, "Now as for your stews, the care of feeding is

Fig. 11.—ADULT SALMON.

Fig. 9.—YOUNG SALMON.

Fig. 10.—SALMON OR PARR, A YEAR OLD.

best entrusted to a butler or a gardener, who are or should be always at home, because the constancy or regularity of serving the fish conduce very much to their well eating and thriving, for they will expect their meat as duly as horses, and appetite in any creature wastes by disappointment. Any sort of grain is good to feed with, especially malt coarse ground; pease boiled a turn or two are as good as any other grain; the grains after a brewing, while they are good and sweet, are very proper; but one bushel of malt not brewed will go as far as two of grains. The chippings of bread and orts of a table, steeped in tap-droppings of good strong ale, are very good food for carps. Of these, the quantity of two quarts to thirty table-carps every day is sufficient; and to feed morning and evening is better than once a day only." But who thinks of feeding their carp now, unless it is those who are supported by voluntary contributions in the marble basins of Hampton Court? The profit would be still the same if not greater than in former years, and there is an obvious tendency to return to a practice which gave those commercial advantages which water-owners formerly derived from judiciously improving the breed and breeding of fresh-water fish, and the large amount of good they did to the community by the great quantity of wholesome food they brought into the markets of both town and country. Jews are at present the principal purchasers of fresh-water fish, and they are not indifferent to their culture, and would doubtless assist in supporting any well-arranged system for their increase and constant supply.

The pursuit of fish farming is, however, not quite extinct in this country, although we question whether the stock is not in general left to itself to increase and to multiply and find its own food. The last which we glean of the custom is from G. A. Cooke, who speaks of the numerous fish ponds in Sussex as being of considerable consequence. "The ponds," says he, "in the wealds are innumerable. The mill-ponds also raise large quantities of fish; they are an object of sale. A Mr. Fenn of London was once the sole monopoliser of all the fish sold in Sussex. Carp is the chief stock, but tench, perch, eels, and pike are raised. Mr. Milward has drawn carp from his marl-pits, 25 lb. a brace, and two inches of fat upon them, as he fed them with peas. The usual season for drawing the ponds is either autumn or spring; the sale is regulated by measure, from the eye to the fork of the tail. At 12 inches, carp are worth 50s. to £5 the hundred, of course, to sell again; at 15 inches £6, and at 18 inches £8 or £9. The late Lord Egremont had several noble ponds for breeding, and others for fattening, with streams running through them. They were fished every third year, and the best reserved for the stews."

The establishment of railways and the facile and cheap carriage of salt-water fish into the interior of the country, where at one time a mackerel or sole was a luxury, has tended much to the neglect of fish-farming as a producer of food; but the rapid spread of the love for angling promises to restore most of our neglected waters to that condition from which they

have fallen. To show, indeed, what a subject of interest angling has of late years become, we need only instance the fact that a comparatively few years ago, there existed but one journal, that of *Bell's Life in London*, which gave especial attention to the subject, and that now every newspaper of ordinary intelligence opens its pages to its doings, comments freely upon the pursuit, and devotes leading articles in sensational and encomiastic language in praise of its healthful tendencies and innocent delights. Moreover, senators retire with the rod to the torrent-side, have their achievements as duly chronicled as the recess speeches of other members of the Legislature; and the professional man no longer conceals his tackle as he makes his way out of town, but rather parades it outside cab or on railway platform, as the welcome companion of his rambles rather than an evidence of idleness; and consequently those rods which under the guise of walking-sticks had once such a sale, are now scarcely to be obtained, much less hypocritically used and patronised by those who were accustomed to disguise part of their purpose in their errand after health.

Perhaps the disgraceful state of non-cultivation is evidenced by the shameful manner in which the Norfolk broads and rivers are netted during the spawning time, with only the paltry excuse that the fish are wanted as bait for salt-water fisheries or for the pigs. Mr. Alexander Russel, in his excellent work upon "The Salmon," says, "Water as well as land was designed to provide food for man; and not only is there no reason why man should destroy the one source, while he is laboriously fostering the other, but there is no obstacle in Nature to water being, like land, rendered immensely more productive by the appliances of art and skill. The fact, however, that Nature, for whatever ends, has made the water more prolific than the land, is no reason at all why man should reduce the water to sterility while making such efforts to maintain and increase the fertility of the land—nay, should even destroy the water with what might further enrich the land. For it is a fact that, whilst the utmost that skill, capital, and labour could do, has been done for the land, not only has nothing been done *for* the water, but a great deal has been done against it, as especially enormous mischief is done by materials that should be kept to give fertility to the land, being sent away to inflict sterility upon the waters."

"The main cause why all fresh-water streams become sterile in the end, if not carefully tended, is simple enough; namely, all the smaller streams form the sewers of the adjacent country, and fall into the larger rivers, and the latter again act as the sewers of the towns and of the kingdom, and are carriers of their congregated impurities finally to the sea. The increasing population of human beings charges the rivers every day with more and more foul matters, the refuse of towns and the agrarian districts passing into them, and hence the destruction of the spawn, egg, or ova of fish, *but not of the fish when once brought into life.*" Had Mr. Boccius lived till 1871, he would have expunged the words written in 1848, which we place in italics, the contrary of which he seems half prepared to admit when he adds: "One cause of this I shall explain chemically. Water is composed of one volume of oxygen gas and two volumes of hydrogen gas. No life can be sustained without oxygen, let it be animal or vegetable; consequently, when water becomes thickened by other matters, a new compound is introduced, which produces a new chemical action; and this is the cause why all rivers and streams eventually become barren; for the following is the result of such a condition of waters, which it is an abuse of language any longer to call fresh. The egg of a fish, in production, differs from that of other animals, as the absorption of the spermatic fluids does not take place till it has passed from the parent, and is then left on its bed, hill, or weed, according to the description of the fish, until the period of incubation has arrived; but in the meantime, should the water become foul and change its character, then the alluvial deposit in the water settles down upon the pedicle or neck of the egg, hermetically seals the same, and prevents the oxygen gas (the component part of water) from being absorbed and passing to the embryo, from which cause suffocation takes place, and the egg is, in the common phrase, addled. This may seem strange, but the student of the laws of Nature well knows that oxygen gas is as absolutely necessary to life as it is the slow destroyer of all things. The destruction of the eggs of the trout from the cause just assigned, I have proved to many friends, having shown them thousands in a putrefied state on their own natural hills or breeding grounds; whilst, upon the principles I have to detail of my methods of producing fish, not a single egg is lost."

The above extract calls for two observations we deem of no little importance. The first is the assertion that the sewage has no effect upon the fish when once brought into life, which all subsequent experiments have proved to the contrary; indeed, so much so that in the Thames and other rivers, it is now admitted that it is a scandalous waste of money and embryo food to introduce salmon, which Mr. Boccius rightly calls "the superior class and quality of fish," until the waters are in such a state of purity as to be prepared for its maintenance.

As regards sewage, we could show by numberless facts that the aristocratic salmon and trout, and indeed several other fish of cleanly habits, will turn tail at the slightest indication of filth; and it is well known upon salmon rivers, that if the smallest portion of putrid garbage, or even the offal of a lamb, is thrown into the stream, it will turn the course of the passage of the fish, and detain them until the effect of the offensive cause is removed. The conditions being, therefore, at the worst, it would actually better pay us to breed in the Thames for sport the coarser kinds of fish, which are more capable from their nature to battle for a while with the foul state of the waters, than are the more sensitive and refined. "Is it not monstrous," says an indignant ichthyologist, "that we are to listen patiently to the minute instructions of how to keep clean and free from offensive particles the troughs and boxes in which we would breed the salmon and trout, and then to hear that after an education in the strictest sanitary *school* of cleanliness, we may safely turn them out into rivers where the state of the impurity may be measured by the depth in inches of a slimy mud deposit, and the poisonous character of their flow ascertained by the absence of the wild flowers that once adorned the banks of the stream?" 120,000 trout which Mr. Boccius bred and turned into the Colne would now have had their millions of great-grandchildren (that is, always subject to the maximum of support a water can afford), and the Wandle its beautiful tenants in profusion, if the one great condition of purity had not been neglected or shamelessly ignored. Paper mills, cotton factories, tanneries and chemical works have much to answer for; but until their owners can see that "waste" can be rendered an item of profit, or they are compelled to find other channels than a running stream for the vehicle of what they desire to remove to their neighbour, the pursuit of artificial hatching must be attended with considerable cost, and, what is still of greater consequence to the advance of science, disappointment, which means serious retardation.*

Who, let me ask, ever found salmon, salmon trout, trout or grayling, or indeed barbel or gudgeon in waters with a muddy deposit; and who that knows anything of the subject expects fish to stay in waters thus situated longer than they could possibly help, or else become sick and die? "In order," says Mr. Boccius, "to prove to demonstration the destructive effects of the deposits of a river when its waters become impure, I had a small bend made from the stream, which was well gravelled, and guarded at either end with perforated zinc plates, and the top covered over, so that neither water-fowl nor heron could ravage the hill. It was spawned with more than 10,000 eggs; but notwithstanding the seeming prospects, not more than a dozen fry came forth, the remainder being all addled."

As our object is more of fact than of theory—of what is than what was—we shall not follow fish culture back any great way—indeed, not farther than will serve to introduce the present practices, and render them plain and practical. It may here be remarked, that provided always the waters are kept free from deleterious matters, and unfair deterioration by poachers, etc., their wonderful productiveness in the shape of fish is beyond question. "There is no animal in the world like the fish in its power of multiplying its own species; but fresh waters require care and protection; they must be managed as well as protected, and they must be protected and managed on sound principles, or all rivers and streams running through populous countries

* See Pollutions in Report of Scotch Fisheries, 1871.

will be in no long time wholly depopulated of their finny tribes."* This was written by our late friend Mr. Gottlieb Boccius so far ago as 1848, and the consequences in many districts have too surely followed this prophetic and almost unheeded warning. Happily, most classes are now alive to the vital importance of our fisheries, and we need not fear, with the mental resources and indomitable perseverance around us, that so great a slur will be permitted long to remain. The people's healthful food and the people's healthful recreation are now engaging the thoughts of active minds. The direction which such benevolent aspirations must take, cannot otherwise than embrace the hundreds of miles of water which flow over or lie quiet upon the surface of Great Britain, all courting the protective hand of man, either to remove those causes of their barrenness and sterility, or to watch over and develop the countless stores of fish which they are ready and willing to offer us. To show how much legislative interference is needed, we could instance very many lengths of water, from two miles to thirty, which possess every essential requisite for breeding fish, provided they were restored to their former purity and properly protected. Yet these valuable resources are given up year after year to the devastation of the net, which scarcely leaves any fry behind, being replenished again and again from neighbouring preserves, only to be thus annually depleted to the profit of those who neither take part in nor pay for the cost of the production of the stock. Hence the importance of the mesh of the net being fixed by competent authorities after due local inquiry (as every river has its own peculiarities), the object being to catch the adult marketable fish, leaving the younger to keep up the stock—in other words, "a mesh to catch all the sheep and let the lambs through." The produce of Scotch salmon fisheries is valued at £300,000 per annum. The rental of the Tay alone is £17,000 a year, and that of Irish rivers is very considerable. The Norwegian and Swedish fisheries improve their rentals every day, the principal returns being from anglers. But from what we hear of the increase of seine and bag nets in their estuaries, it may not be long before resort will be had to fish culture. Still, with the absence of all pollutions from most of their rivers, it may be long before any serious mischief occurs.

The Rhine runs through Holland, France, Prussia, and Switzerland, and although there may exist a difference of opinion in these countries in regard to national boundaries, there is none in reference to the capabilities of the Rhine as a salmon-producing stream. Consequently the importance of the subject has given rise to a society now in operation at Berlin, under the highest Government officers of the several interests, Der Deutsche Fischeriei Verein, which is about at once to undertake the fish cultivation of this river. There can be little doubt but that the Rhine is capable of producing many thousand pounds worth of fish, if a proper understanding can be arrived at amongst all parties, although the canalising that river, while improving its channel for navigation, has had a deteriorating effect upon its natural basin as a nursery for fish.

The managers of Der Deutsche Fischeriei Verein are in correspondence with the leaders of fish culture in England, as in this art it is now generally acknowledged that this country takes the most forward place in Europe. Indeed, in regard to salmon culture, Great Britain now stands unrivalled. There are thirty-four district boards in England under the acts of 1861 and 1865, who carry out fish culture on a very large scale, regulating nets, fixed engines, ladders, weirs, preventing pollutions, and, above all, giving protection to the fish in the winter time. All the large Scotch rivers are under the management of a board of the most influential people of the country: Ireland also is divided into districts which work under Irish Acts of Parliament. In England and Wales, inspectors are appointed to travel about and advise, and report annually to Parliament. There are special commissioners appointed to inquire into law points as to rights of salmon property. In Ireland there are three inspectors, who also issue annual reports. These gentlemen likewise have to watch the oyster and sea fisheries. There are three Scotch commissioners whose duties are more legal than executive, and we learn from the latest report that the Scotch proprietors in the district board are anxious for inspectors to be appointed to carry out provisions of schedules, especially G, as to passage of fish over weirs, and Schedule F, regulation of cruves (fishing traps), gratings, annual close time, meshes of nets, and other details of importance. Sweden, Russia, and Denmark have also inspectors of fisheries, and so also has Canada. America appears, however, but recently to have awaked to their necessity, and this has been brought about by the announcement that the shad are nearly extinct, and the salmon are being rapidly exterminated by the increasing quantity of saw-dust accumulating in the principal rivers from the water-mills. The states of New York and Boston are taking great pains to open up rivers, and increase the fish by artificial hatching. Mr. Seth Green has done much in the latter direction. His last useful act was to transport shad to the rivers of California. Mr. Andrew Murray, F.L.S., has brought the eggs of the sterlet from Russia, and turned them out in the Shin, under the auspices of his Grace the Duke of Sutherland.* Sir Stephen Lakeman has brought over three living specimens of the gold schley, now quite naturalised in this country at Aldermaston Park, near Reading, the seat of Mr. Higford Burr, a zealous and practical naturalist. Sir Stephen Lakeman likewise succeeded in introducing the thunder-fish and the *Silurus glanis* into this park, but the experiment failed, the fish having unaccountably disappeared, but they probably fell a prey to the herons, a colony of which is close by.

We append some excellent illustrations of the salmon in three different stages: (1) the young salmon during the early stage of its existence; (2) the parr, or salmon a year old; and (3) the adult or full-grown salmon.

* The spawn of fish ought to give us some notion of what is lost to us for want of extended protection. The following is from Buckland's "Fish Culture:"—

	Weight of Fish.	*Total No. of Eggs.*
Salmon	20 lb.	17,500
Trout	1 lb.	1,008
Jack	$4\frac{1}{2}$ lb.	42,840
Perch	$\frac{1}{2}$ lb.	20,592
Roach	$\frac{3}{4}$ lb.	480,480
Smelt	2 oz.	36,652
Lump Fish	2 lb.	116,640
Brill	4 lb.	239,775
Sole	1 lb.	134,446
Herring	$\frac{1}{2}$ lb.	19,840
Mackerel	1 lb.	86,120
Turbot	8 lb.	385,200
Cod	20 lb.	4,872,000

* Vide *Field Quarterly*, Feb. 1871, page 33.

BRICK AND TILE MAKING.—V.

By Gilbert R. Redgrave.

COPING BRICKS—MOULDED BRICKS—GAUGED BRICKS—TILES—ROOFING AND DRAIN TILES.

Before passing on to the manufacture of tiles, it may be as well if we glance briefly at some of the many descriptions of bricks. These, as may be supposed, are almost endless, and we can only, in the space at our command, refer to a few of the chief of them. Coping bricks are used to surmount walls, and are so shaped as to throw off the water, and provide a slightly overhanging protection to the wall; they are, therefore, generally rounded, or made with a slant or double slant at the top, and should be provided on their under surfaces with a slight groove on each side, in order to form a drip to throw the wet off the wall. They are seldom made for walls more than 14 inches in thickness, and should be one inch wider on each side than the wall—thus, 11 inches for 9-inch brickwork, and 16 inches for a wall 14 inches wide. Moulded bricks are made in every variety for enriched surfaces, and take their names from the shape of the principal moulding on them: arch-bricks are those made in the form of a wedge, in order to serve as voussoirs; splayed bricks, such as have one of their edges canted off, and are employed for set-offs and plinths; compass bricks, used for building circular walls and sewers; channel bricks, for gutters; clinkers, specially made for paving; and bond bricks, which are from 14 to 18 inches in length, and are used to improve the bond of common brickwork. There are also special names in different parts of the country for the various qualities of bricks, with reference to the respective excellence of their manufacture; thus the best, according to the nature of the brick, may be called malms, rubbers, or cutters; the seconds, stocks, or malm stocks, and grizzles; and the inferior and

underburnt kinds, shuffs, sammel or place bricks. Those which are so overburnt and run together as to be quite valueless, are called clinkers or burrs, and are broken up and used for road-making. In accordance with the way in which they are made, bricks are sometimes called pressed bricks, or patent bricks, which latter term is applied indiscriminately by bricklayers to all machine-made bricks.

By the Act of Parliament now abolished, which imposed a tax of 5s. per thousand upon all bricks under a certain size, and double this amount on all such as exceeded $10 \times 5 \times 3$ inches, which are rather in excess of the dimensions of an ordinary brick, it was also impossible to go over or dress the surfaces of any bricks, after they had once left the mould, without rendering them liable to an increased duty of 12s. per thousand. Under these circumstances, it is scarcely to be wondered at that for many years little was attempted in the way of improving this branch of manufacture. The Act of 1839, which made this duty a uniform sum for all bricks under 150 cubic inches in contents of 5s. 10d. per thousand, opened up an important and neglected industry, which has since then made great progress, and moulded and enriched bricks are now largely used for London buildings.

London, owing to the scarcity of stone in its vicinity, must always remain a brick city, and it is sad, knowing this to be so, to see how little has been done by London brickmakers to improve the ordinary stock brick, which is about as bad as it well could be.

Before concluding our remarks upon bricks, we may refer very briefly to the plan of using them as gauged or rubbed bricks. It was a very common practice in the "Queen Anne period" to put together a number of carefully-burned bricks, picked for evenness of colour, with the thinnest possible joints, and then to carve some ornament on this mass, dealing with it as if it were a block of stone. For all the best kinds of walling, moreover, the bricks were similarly selected for colour, and rubbed on a stone slab, to make the joints as thin as possible. The face of the finished wall was likewise rubbed over with a hard brick, till it was perfectly level and true. Such work constitutes the fine old red brickwork, which is frequently so much praised. A somewhat similar mode of preparing and using brick is now again coming into vogue; and opposed as it is to the nature and properties of the material considered with reference to its brick origin, we cannot but protest against this method of dealing with brickwork. To cut and carve bricks into all kinds of elaborate shapes when they have been hardened in the kiln, and to do at so much expense, when the clay has been burned, that which could have been so readily and cheaply done while it was in the plastic state, appears to us to be entirely wrong and false in principle. It does not come within our province to point out the best modes of using bricks, nor have we anything to do with the mortar or cement used for this purpose. On the vexed question of thick and thin joints, we may state that we are of opinion that a joint of about a quarter of an inch in thickness, as one which can readily be made with the ordinary consistency of mortar, and as furnishing a good and true bed for a fairly well-formed brick, should be insisted upon. The plan of making bricks with a large frog or kick on their upper and under surfaces, and of filling some kinds of bricks with small perforations, while it is by no means injurious, decreases their weight, and gives the mortar a good hold. We may conclude this part of our subject with the following simple directions: "Well wet your bricks before laying them, and let your mortar be as stiff as possible."

We shall divide our observations upon tile-making into two heads—namely, roofing and drain tiles, and flooring and wall tiles. Tiles specially intended for use as a roofing material have not, we think, the same antiquity as bricks. The ordinary roofing tile, known as a plain tile, which generally measures $10\frac{1}{2} \times 6\frac{1}{2} \times \frac{5}{8}$ inches, and weighs about $2\frac{1}{4}$ pounds, seems to have been made on the model of a shingle. Shingles are thin strips of split wood used in the same way as tiles are used, and which in many parts of Germany and Switzerland, and even in some of our own rural districts up to the present day, are in almost universal use for every description of roofing.

The introduction of slate, owing to the increased facilities of railway communication with Wales and other slate-producing districts, seemed likely for a time to drive tiles completely out of the market. The weight of the tiles may be assumed to be about 15 cwt. per square of 100 superficial feet, while the same amount of roof space could be covered with 5 cwt. of the best slates. Then the slates are so much less porous, so much more readily fixed, and can be laid at so much flatter an angle than tiles, that for these and other similar reasons they have very largely replaced the old-fashioned tiling. It cannot, however, be forgotten that slating is a very dull and ugly looking substitute for tiling, and as tile manufacturers have recently been exerting themselves to give us a better made and lighter article than the old-fashioned pan or plain tile, we may hope to see tiles again largely used. Pan-tiles are larger than plain tiles, have an ogee section, and weigh about $5\frac{1}{4}$ lb. each. Both pan and plain tiles, and several other varieties we shall allude to further on, are generally made by brickmakers, and require appliances similar to those described for brick-making. Plain tiles can readily be made by machinery, but we are not aware that any machine exists for the production of pan-tiles.

The clay for tile-making requires to be of a tougher description than that used for bricks; and, as it will readily be understood, owing to the much greater thinness of tiles, requires a much more careful course of preparation. It is generally dug in the autumn, and allowed to remain all through the winter months in shallow pits, to fall and mellow, and is sometimes kept for a twelvemonth before it is used; it has to be carefully picked over to remove the stones, and it is generally tempered before use in small lumps by women or children, or it is passed twice, and sometimes three times, through a pug-mill. Having been further prepared by cutting it into numerous thin slices with a wire cutter called a sling—which process assists in removing the small stones, and is similar to the wedging or slapping of the terra-cotta clay—the clay is ready for the moulder. The lumps or pieces are roughly prepared by a boy in thin slices, about large enough to fill the mould, which is nothing more than a wood frame, a little over half an inch in thickness. Tiles are invariably made in sanded moulds, as slop-moulding cannot be employed. In Staffordshire coal-dust, and in Shropshire powdered burnt clay is used to facilitate the object leaving the mould. The clay having been filled into the mould, the surface is levelled, in some places with a wire cutter, in others with a round roller, like a cook's rolling-pin. The tile is then removed to dry, and when partially dry it is beaten with a thwacker, or placed upon a horse, to give it what is termed a set. The set is a slight curve, which is necessary in order to enable the tiles to bed evenly one upon the other when used for roofing. When thoroughly dry, the tiles are stacked in kilns, and burnt as bricks are burnt. It is a very common practice to burn bricks and tiles together, the bricks being at the bottom of the kiln and the tiles at the top. The tiles are built up on edge, as close as they will lie, in layers or "bolts," which cross one another at right angles. When they are burnt alone they do not require so much firing as bricks, in consequence of their small thickness.

It was formerly customary to punch a couple of small square holes through the tile, about $1\frac{1}{2}$ inches in each way, at the top; through these holes wooden pegs were driven, by means of which the tile was hung upon the lath. This system has now been discontinued in most places, as not only was the tile much weakened thereby, and frequently broken by the insertion of the pegs; but it was also found that the dampness of the tile soon rotted the peg, which dropped off, and allowed the tile to slip off the roof. In lieu of the holes, therefore, a small stud or button of clay is cast on the under surface, just against the upper edge, which most effectually replaces the peg.

In making pan-tiles, the tiles are first moulded flat, and then given their proper curve on a specially-formed block. They are subsequently, when partially dry, trimmed up and finished on a thwacking-frame, and burnt in a special kiln. For a more minute description of what is, however, now an almost obsolete manufacture, our readers are referred to the article on "London Tileries," in "Dobson's Treatise." In Shropshire and Staffordshire a very small and thin tile is made of the well-known blue clay, which is burnt very hard, and which, owing to its imperviousness and lightness, makes an excellent roof material: such tiles are termed Broseley tiles.

Plain tiles are very frequently ornamented by having their lower ends made pointed or rounded off, and when used in alternate courses with common tiles, they have a very good effect. Such tiles are made in a similar way to the plain tiles, in a

special mould. This kind of tiling is often used against the vertical wall of a house or cottage to keep out the driving rain, and in this form it is known as "weather tiling." The special tiles for covering the ridges and hips, and for forming gutters —known respectively as ridge, hip, and valley tiles—are hand-moulded on blocks shaped for the purpose; they are about the same price as pan-tiles. Ridge tiles are difficult to burn, and are generally placed one within the other on the top row of the kiln.

Drain tiles are properly small pipes: they were at one time made sectionally in the form of a horse-shoe, and were placed in the ground in the trenches prepared for them, with the open part downwards. In soft soils such draining was of very little use, as in a very short time the superincumbent weight pushed the tile down into the earth, and thus filled it up. These tiles, which were moulded flat and subsequently bent to the required shape, are, we believe, now no longer made. The ordinary circular drain tile, which may be from $1\frac{1}{2}$ to 3 inches in internal diameter, is made in a machine of simple construction, which can be readily worked by hand. A man and boy can turn out 4,000 or 5,000 in the course of a day. Before the introduction of these machines a strip of clay had to be rolled out or moulded of the required size, and then wrapped round a drum or mandril, the edges closed by hand, and after the tile had been shaped and finished the drum was withdrawn, and the tile stood upon end to dry.

There are numerous pipe-making machines now in use which are almost exactly similar in principle: the clay is first prepared in a pug-mill, and then pressed through an aperture in a steel die; the pipe is cut off from time to time, to any required length, by means of a wire cutter. Some machines make three or four tiles at each stroke of the piston. One of the most recent inventions is a machine for producing pipes by hydraulic pressure, which seems to work steadily and well. Pipes are stood on end, and built up one on the top of another, in the kiln. If it is required to give them a salt glaze, the fires are made up just as the kiln has got to its full heat, and a few handfuls of salt are thrown on each fire. The salt sublimes, and the soda therein combines with the silica in the clay to form a fusible double silicate of soda and alumina. Salt glazing is, we believe, almost invariably confined to down-draught kilns. A ring wall about half way up the kiln protects the goods from immediate contact with the flames, which pass up over this wall through the goods, and escape by means of numerous openings in the floor into the chimney. Pipes, tiles, and all thin clay goods, though they do not want quite so much care as more solid objects in the smoking process, require very careful and tender treatment under full firing.

In the production of simple ornamental roofing tiles some of our Continental neighbours are far ahead of us: there have been latterly, however, several new kinds of tiling brought under our notice. Among these are the corrugated tiles, made at Bridgewater, the Broomhall tiles, which are ribbed or fluted, and the so-called Italian tiles, which are a combination of rolls and flat tiles. The true Italian tiles are all semi-circular, and are laid alternately convex and concave. The mode of repairing leaky roofs in Italy may be all very well there, but would not do, we fear, with our lightly timbered English roofs. It consists in laying another layer of fresh tiles over the leaky ones, which are left as they are. We have seen old roofs in Milan with three or four thicknesses of tiling on them. For producing plain and moulded tiles by machinery the appliances are all of them similar to those previously described for brick and pipe making. We shall pass on in our next paper to the manufacture of flooring tiles.

AGRICULTURAL CHEMISTRY.—XI.

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CHAPTER XI.—CHEMISTRY OF FEEDING MATERIALS.

A KNOWLEDGE of the composition of feeding materials and of their comparative values is of great importance to the scientific farmer. No doubt the relative values of the ordinary foods consumed by the animals of the farm are tolerably well known to feeders who have had considerable experience in their business; but there are many alimentary substances occasionally employed in the feeding-house, of which the stock-feeder's knowledge is very limited. Indeed, it may truly be said that the great majority of farmers are by no means fully acquainted with those methods of fattening their stock, which out of a *minimum* quantity of raw materials (foods) produce a *maximum* amount of beef, mutton, and pork.

The space at our disposal does not admit of our going minutely into the physiology of the animals of the farm, or the chemistry of food: we can but state the composition of the principal nutritive substances used in the feeding-house, and briefly indicate their adaptability to the wants of the different varieties of stock.

The proximate ingredients of vegetables used as food are arranged under three heads:—

(1) Nitrogenous, albuminous, or flesh-forming bodies, containing the chemical elements, carbon, hydrogen, oxygen, nitrogen, and small proportions of sulphur and phosphorus; (2) non-nitrogenous or fat-forming bodies, containing carbon and the elements of water, hydrogen and oxygen; (3) mineral or incombustible matters, or *ash*. Caseine, albumen, and fibrine are examples of nitrogenous bodies, and they resemble each other and all other albuminoids very closely in composition. Sugars, starch, pectose bodies, gum, and woody fibre (cellulose) are termed carbo-hydrates, and together with oleaginous or fatty bodies, they constitute the non-nitrogenous group of food materials. In nutritive power it is considered that $2\frac{1}{2}$ parts of digestible carbo-hydrates equal 1 part of fatty matter. We do not know of any difference between the nutritive power of the various albuminous substances. Cellulose is, there is good reason to believe, digestible in the stomach of a ruminant, provided it be derived from young and succulent plants; old woody fibre can have but little, if any, nutritive properties. Pectose bodies constitute a rather large proportion of the nutritive matters found in roots and foliage. Pectose proper is the substance, the presence of which in the juices of various fruits, causes them to gelatinise; hence pectose is also termed vegetable jelly. As to the nutritive property of gums some doubt has been expressed, but we believe that they really do possess alimentative properties. We shall now describe the composition of the commonly employed feeding-stuffs.

Green Food.—The grasses, natural and artificial, constitute the most abundant food of live stock. Amongst the most nutritious grasses may be enumerated Italian rye-grass, annual meadow-grass, meadow barley, crested dog's-tail-grass, Timothy, or meadow cat's-tail-grass, cock's-foot-grass, and sweet vernal grass. Amongst grasses of medium quality may be mentioned smooth and rough-stalked meadow-grass, meadow foxtail-grass, and waterwhorl-grass. The rough-stalked meadow-grass is perhaps the least nutritious of those mentioned; but it is superior to meadow soft-grass, false brome-grass, upright brome-grass, and creeping soft-grass, which, together with other kinds grown, do not deserve to be cultivated.

In grasses we find from 70 to 78 per cent. of water, 2 to 4 per cent. of albuminates, about 1 per cent. of fatty bodies, 10 to 20 per cent. of fat-formers (starch, etc.), and from 5 to 15 per cent. of woody fibre.

The artificial grasses (which on the whole are more nutritive than the natural grasses) include the different varieties of clover, vetches, lucerne, and a few other plants, most of which are rarely cultivated. Clovers are very valuable plants, rich in both flesh and fat forming materials, and very succulent and tender. Of the different varieties *alsike* appears to be the best, as it contains a very high proportion of nutritive matter, besides usually giving an abundant yield. The composition of the vetch, sainfoin, and lucerne closely resembles that of the clovers. Lentils, birdsfoot, trefoil, melilot, and lupines are leguminous plants, and are all valuable forage crops.

According to Dr. Anderson, red clover contains from 79·98 to 85·3 per cent. of water, 14·7 to 21·02 per cent. of dry substances, 2·31 to 2·87 per cent. of albuminates, and from 1·3 to 1·58 per cent. of ash; cow-grass contains from 77·39 to 81·76 per cent. of water, 18·24 to 22·61 per cent. of dry substances, 2·25 to 3·19 per cent. of albuminates, and 1·92 to 2·73 per cent. of ash; crimson clover contains 82·56 per cent. of water, 17·44 per cent. of dry substances, 3·25 per cent. of albuminates, and 1·88 per cent. of ash; yellow clover contains from 77·38 to 78·60 per cent. of water, 21·4 to 22·62 per cent. of dry substances, 2·94 to 3·5 per cent. of albuminates, and from 1·75 to 2·02 per cent. of ash. Green rye is occasionally employed as a forage crop; it is about equal to good clover.

Rape is one of the most valuable of the crops used for stock-

feeding in these countries; not because its feeding value is high, but simply owing to its being generally obtained as a *stolen* crop, that is, a crop obtained from a field which has produced or is to produce another crop in the same year. 100 parts of rape contain, according to Voelcker, 87·05 per cent. of water, 3·133 per cent. of albuminates, 0·649 per cent. of fats, 4 per cent. of starch and gum, 3·56 per cent. of fibre, and 1·608 per cent. of ash.

The mustard plant is sometimes grown for sheep. It is richer in flesh-formers than rape, and in other respects it is about equally nutritious with the latter. The prickly comfrey, chicory, and yarrow (the latter is usually considered to be little better than weeds), are all somewhat inferior to clover and rape. Melons and marrows are occasionally used as food for cattle, but their nutritive power is very low. The cabbage possesses very good feeding properties, and is worthy of greater attention from the stock-feeder. Dr. Anderson has investigated the composition of the drumhead cabbage. He found that the "heart" and inner leaves were less nutritious than the outer leaves, and that the young plants were the richest in nourishment. These results show the desirability of cultivating the open-leaved varieties of this plant. Cabbages are much relished by cattle and sheep, and the butter of cows fed upon them is free from the disagreeable flavour which is often noticed in butter from the milk of cows fed on turnips. It is to be regretted that cabbages do not admit of being stored, as otherwise they might be much more extensively cultivated than is now the case.

The following is Voelcker's analysis of the cattle cabbage (heart and inner leaves in a fresh state). 100 parts contain:—

Water	89·42
Oil	0·08
Soluble albuminates	1·19
Insoluble albuminates	0·31
Sugar, digestible fibre, etc.	7·01
Woody fibre	1·14
Ash	0·85
	100·00

Furze (gorse or whins) is a plant that might with advantage be grown upon poor soils, especially in the uplands. It is very hardy, and is able to withstand prolonged drought. It is relished (when bruised) by every kind of stock, and even horses thrive upon it. I find furze cut on the 15th of August, the shoots mostly consisting of the year's growth, to have the following composition. 100 parts contain:—

Water	72·00
Albuminates	3·21
Oil	1·18
Fat-formers (starch, etc.)	8·20
Woody fibre	13·33
Ash	2·08
	100·00

Dry Fodder.—Straw consists of the dried stems of cereal and leguminous plants. Most kinds are valuable foods, and indeed it appears to me that farmers do not estimate at the full value the feeding properties of good oat and barley straw.

The quality of straw is very much influenced by the manner in which it is harvested. If it is cut early, speedily removed from the field, kept from the wet and properly stacked, it will often (in the case of oat-straw) be found to closely approach hay in nutritive value. When the upper part of the stems of corn plants changes from a green to a yellowish hue, nothing is to be gained by delaying the reaping of the crop. The change of colour indicates that the vegetative functions of the plants have come to an end, and that henceforth, instead of increasing, they will diminish in weight, and that they will certainly deteriorate in quality the longer they remain uncut. Over-ripened straw is often of very inferior quality, whilst the stem, cut whilst a large portion of it is still green, is one of the best staple foods of both horned stock and horses. Perhaps the best way to give a clear idea of the value of straw properly harvested, is to compare it with linseed-cake in the following manner:—One ton of good oat-straw (at say 30s. per ton) contains 22·4 lb. of oil, 89·6 lb. of flesh-formers, 224 lb. of sugar, starch, gum, and 672 lb. of digestible woody fibre = 1,008 lb. of nutritive matters; or if we calculate the fat as being equal to $2\frac{1}{2}$ times its weight of starch, then the total nutriment would be—fat-formers, 952 lb.; flesh-formers, 89·6 lb.; total, 1,041·6 lb. On the other hand, one ton of good linseed-cake (at say £11 10s. per ton) contains of flesh-formers, 582·4 lb.; fat-formers (oil, 268·8 lb., gum, sugar, etc., 761·6 lb.), 1,508; fibre, 74·4 = total nutriment (the fats being multiplied by 2·5), 2,090·4 lb. These comparisons show us that we get 1,000 lb. weight of nutriment in the form of straw for 30s., whilst for the same weight of nutriment in the form of oil-cake we pay £5 15s. No doubt, in the matter of quality, and in the presence of a large proportion of ready-formed fats, the oil-cake is superior to the straw; nevertheless, these advantages appear to be purchasable at a very high cost.

ANALYSES OF OAT-STRAW.

	From Co. Wicklow.	Obtained in the Dublin Market.		
	No. 1.	No. 2.	No. 3.	No. 4.
Water	14·00	14·00	14·00	14·00
Flesh-forming principles—				
a. Soluble in water	4·08	2·02	2·04	1·46
b. Insoluble in water	2·09	3·16	3·00	2·23
Oil	1·84	1·40	1·26	1·00
Sugar, gum, and other fat-forming matters	13·79	12·67	10·18	11·16
Woody fibre	59·96	61·79	65·45	65·29
Mineral matter	4·24	4·96	4·07	4·86
	100·00	100·00	100·00	100·00

No. 1 was barely ripe; the others had been allowed to remain far too long uncut.

ANALYSES OF WHEAT-STRAW.

	Green changing to yellow. County Kildare.	Ripe. County Dublin.	Over Ripe. County Dublin.	Obtained in the Dublin Markets.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Water	13·00	13·15	12·14	10·88	11·22	12·12
Flesh-forming principles—						
a. Soluble in water	1·25	0·98	0·44	0·06	0·42	0·30
b. Insoluble in water	1·26	1·40	1·41	1·90	1·00	1·76
Oil	1·22	1·13	1·14	0·90	1·17	1·08
Sugar, gum, and other fat-forming matters	4·18	3·98	3·88	4·08	3·89	4·30
Woody fibre	75·84	76·17	77·76	78·67	79·18	77·15
Mineral matter (ash)	3·25	3·19	3·23	3·51	3·12	3·29
	100·00	100·00	100·00	100·00	100·00	100·00

With respect to their nutritive value straws stand in the following order, the most nutritious being first:—Pea-haulm, oat-straw, bean-straw with pods, barley-straw, wheat-straw, bean-stalks without the pods.

Hay consists of a different admixture of dried natural and artificial grasses, and its composition is consequently very variable. According to Voelcker, the following represents the average composition of meadow-hay, as deduced from twenty-five analyses of it:—

Water	14·61
Flesh-formers	8·44
Fat-formers	43·63
Fibre	27·16
Ash	6·16
	100·00

According to Way, the herbage of water-grass meadows is richer in nutritive matter than that of dry meadows.

According to Dr. Anderson, the composition of clover hay, of the second cutting, is as follows:—

Water	16·84
Flesh-formers	13·52
Fat-formers and fibre	64·43
Ash	5·21
	100·00

There does not appear to be any difference between the com-

position of the first and second cuttings of hay, if both be saved under the same conditions. Hay should be cut before the plants ripen fully, and even before they flower: enormous losses of its nutritive principle take place from the frequent practice of allowing it to remain in the field for days and weeks exposed to rain and sunshine. In Ireland a competent authority estimates the loss from this source at a fifth part of the whole crop.

Roots and Tubers.—The majority of roots used as cattle food possess but very little nutritive power, but the great quantity in which they are produced renders them a most important and indeed an almost indispensable element in the production of beef and mutton. Tubers are far more nutritious than roots, but the potato is the only tuber generally used in stock-feeding.

ANALYSES OF ROOTS AND TUBERS.
(By Voelcker, Anderson, and the Author.)

	Swedish Turnip.	White Globe Turnip.	Aberdeen Yellow Turnip.	Norfolk Bell Turnip.	White Beet.	Parsnip.
Water	89·460	90·430	90·578	92·280	83·0	82·00
Flesh-formers	1·443	1·143	1·802	1·737	2·5	1·30
Fat-formers	5·932	5·457	4·622	2·962	11·5*	7·75
Fibre	2·542	2·342	2·349	2·000	2·0	8·00
Ash	0·623	0·628	0·649	1·021	1·0	0·95
	100·000	100·000	100·000	100·00	100·0	100·00

	Carrot.	Kohl Rabi.	Potatoes. Regents.	Potatoes. Dalmahoys.	Potatoes. Kerry Blues.
Water	88·50	87·62	76·32	75·91	76·60
Flesh-formers	0·60	2·24	2·37	2·25	2·06
Fat-formers	10·18 (Fat-formers and Fibre)	7·78	14·96	15·53	14·88
Fibre		1·34	5·53	5·21	5·41
Ash	0·72	1·22	0·88	0·81	0·94
	100·00	100·20	100·06	99·71	99·89

Seeds.—The most concentrated and valuable food is that furnished by seeds. Not only do they contain very large amounts of "dry substances," but their ingredients are in the highest degree elaborated or organised, and therefore they can be most easily assimilated by animals.

AVERAGE ANALYSES OF GRAIN.

	Barley.	Bere.	Oats.	Oatmeal.	Indian Corn.	Rice.	Rye (Irish).	Buckwheat.
Water	16·0	14·25	14·0	13·00	14·5	14·0	16·0	14·19
Flesh-formers	10·5	10·10	11·5	16·00	10·0	5·3	9·0	8·58
Fat-formers	67·0	64·60	64·5	68·00	69·0	77·5	66·0	51·91
Woody fibre	3·5	9·03	7·0	1·75	5·0	2·5	8·0	23·12
Mineral matter	3·0	2·02	3·0	1·25	1·5	0·7	1·0	2·20
	100·0	100·00	100·0	100·00	100·0	100·0	100·0	100·00

Oat-grass is the most nutritious of the seed consumed by stock. The white kind is considered the best. The husk of this grain is very inferior to wheat-bran, and oat-toppings are generally not worth the price at which they are sold. Indian corn is a good food, and from its large amount of ready-formed fatty matter it is well adapted for dairy cows and bullocks in stalls. It is excellent food for pigs. Barley is inferior to oats, but still barley-meal is an excellent food, and *barley dust* is often a cheap feeding-stuff. Barley husks should not be given in an uncooked state, as they are apt to irritate the digestive organs. Wheat is not often given to cattle; it possesses a very high degree of nutritive power, and its bran is an excellent feeding-stuff. Malted barley is a good food for milch-cows, but it is doubtful if any advantage be derived from converting barley into malt. Malt combs, or dust, under £4 per ton may be regarded as cheap. They are very rich in albuminates.

* Including 10 of sugar.

Leguminous seeds are rich in flesh-forming elements, and they are consequently adapted for young stock. They are *binding*, and therefore must not be largely used, unless they are combined with some laxative material. These seeds contain from 23 to 26 per cent. of flesh-formers (chiefly *legumine* or vegetable caseine), from 47 to 50 per cent. of fat-formers, and about 10 per cent. of woody fibre. The different kinds of leguminous seed hardly differ in composition.

Oil Seeds (linseed, rape-seed, hemp-seed, and cotton-seed) are not much used as cattle foods on account of their high price. They contain from 31 to 37 per cent. of oil, 22 to 32 per cent. of albuminates, and from 24 to 35 per cent. of non-nitrogenous substances. *Oil Cakes* consist of the residue of oil seeds from which a certain amount of oil has been expressed. The following is their average composition:—

AVERAGE COMPOSITION OF OIL-CAKES.

	Linseed Cake (English).	Rape Cake.	Decorticated Cottonseed Cake.	Poppy Cake.
Water	12	11	9	12
Flesh-forming principles	28	30	38	32
Oil	10	11	13	6
Gum, mucilage, etc.	34	30	23	30
Woody fibre	10	10	9	9
Mineral matter (ash)	6	8	8	11
	100	100	100	100

Linseed-cake is a very valuable feeding-stuff, greatly in use, and more especially in completing the fattening of oxen. The cake should have a reddish-brown colour, a uniform appearance, and a rather agreeable flavour and odour. The adulterated cake is generally greyish, and often has an unpleasant odour. It is sometimes adulterated with earthy matter, in which case its great weight will betray the nature of the impurity. If about ¼ oz. be powdered and mixed with a small wine-glassful of water, the paste should be moderately stiff, light-coloured, and well-flavoured. If, on the contrary, the paste be thin, it is probably adulterated, in which case bran or grass-seeds are probably present. By means of a small magnifying glass grass-seeds and other impurities may readily be detected if present in the paste.

Rape-cake is not so well flavoured as linseed-cake, and although it contains rather more oil and flesh-formers than the latter, its commercial value is more than one-third less. There exists considerable difference of opinion relative to the nutritive properties of rape-cake, some feeders believing it to be fully equal to linseed-cake, whilst others think it dear at half the price of the latter. Rape-cake often contains a large proportion of mustard, and it naturally includes an acrid substance which renders its flavour unpleasant. These are often the cause of the failure of rape-cake as a food for stock. When, however, the cake is free from mustard and of good quality, there is no doubt as to its being a more economical feeding-stuff than linseed-cake. It is much improved by being thoroughly steamed, and the addition of a little molasses renders it very agreeable to cattle.

Palm-nut meal is a very fattening food, containing from 14 to 17 per cent. of fats, from 17 to 20 per cent. of albuminates, and about 52 per cent. of non-nitrogenous matters. Taking into account its high per-centages of nutritive materials, it is a cheap food at its present price. It is largely given to pigs, but cattle at first do not usually relish it on account of its strong flavour; however, they soon acquire a fondness for it.

Condimental Foods consist, in general, of mixtures of locust beans (an article which contains nearly half its weight of sugar), Indian corn, or other grain, and certain aromatic ingredients. The following formula will be found as good as any:—Linseed-meal or cake, 7 cwt.; locust beans (ground), 8 cwt.; Indian corn, 4 cwt. 1 qr.; powdered turmeric, 1 qr. 14 lb.; ginger, 3 lb.; fenugreek seeds, 2 lb.; gentian, 10 lb.; cream of tartar, 2 lb.; sulphur, 20 lb.; coriander seed, 5 lb.; salt, 10 lb.=1 ton and 10 lb. This will be found a better and cheaper preparation for horses out of condition, and for bullocks in the last stage of fattening, than any of the commercial "condimental foods."

TECHNICAL DRAWING.—LI.

GOTHIC STONEWORK.

FIG. 448 is an example of an arch taken from the triforium arcade in the north transept of the cathedral at Chester, probably one of the most ancient of the Norman portions of the edifice. It would be described architecturally as a "semicircular arch of a *single order*, with square edges"—the term "order" being in this case used to designate the course of stones of which an arch is formed.

Fig. 449 is a sketch of the spring of the tower arches of St. John's, Chester, showing the method of construction. There are three courses of voussoirs, forming three receding faces. These arches would be described as of "three orders with square edges;" or simply as "triple recessed arches with square edges."

OF THE ORIGIN OF MOULDINGS.

The first step towards the introduction of mouldings appears to have arisen from the desire to do away with the massive and rude appearance of the square edges, and to lead the eye gradually from the front plane of the wall to the central plane of the aperture, instead of by the sudden step-like rims which a series of "square-edged orders" presented.

The simplest way of doing this is by cutting away or removing the square edge. An arch of two orders with chamfered edges is shown in Fig. 450. It is taken from the ruins of the priory at the east end of St. John's, Chester. It is, however, remarkable, observes the Rev. T. N. Hutchinson (whose excellent lectures and writings on this special section of the subject are often referred to), "that, simple as this method is, it does not appear to have been the first resorted to. The arch in question is of late date for Norman work, if indeed it be not of Transition character. It is also remarkable that this way of removing the square edges of two or three orders continued in use during all the subsequent styles of Gothic architecture."

The earliest attempts at removing the plainness of the chamfered edges consisted in simply rounding them off, thus giving the appearance of a heavy semi-cylindrical ring. The first of the three orders, or "sub-arch," as it would be correctly called, is frequently found rounded off in this way. There is a good example in the south aisle of the choir of St. John's, Chester, a section of which is illustrated in Fig. 451. A more effectual way, however, was generally followed. Instead of simply rounding off the edge, a portion of the stone on either side was cut away, thus leaving the cylindrical roll clearly defined, and affording a more decided effect of light and shade. Fig. 452 is an example of this method; it occurs in an arch in the west cloister of Chester Cathedral, formerly leading to the abbot's apartments. In this figure it will be observed that two of the orders are left with the square edges, the first or sub-arch only having the moulding referred to. The mediæval name of this moulding is the "bowtell," but it is more frequently spoken of as the "Norman edge-roll."

The roll moulding with side hollows appears to have been the only attempt at this kind of decoration in use among the

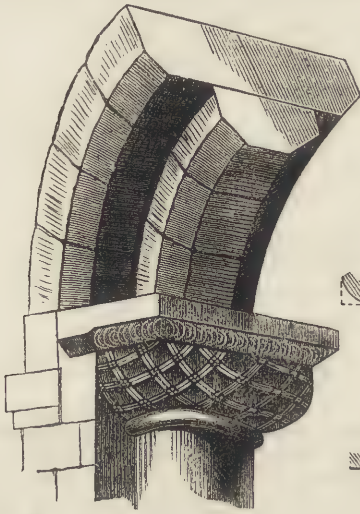


Fig. 450.

Fig. 451.

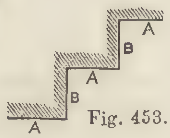


Fig. 453.

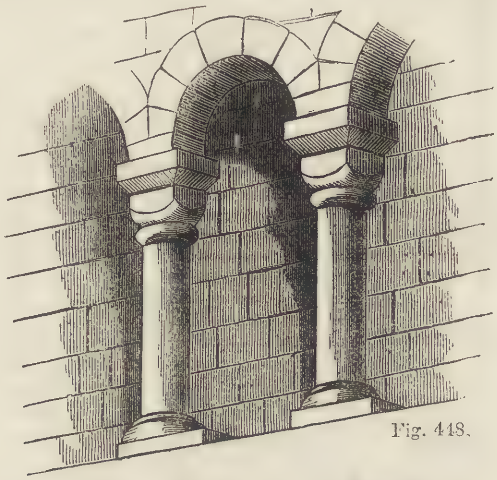


Fig. 448.

Fig. 454.

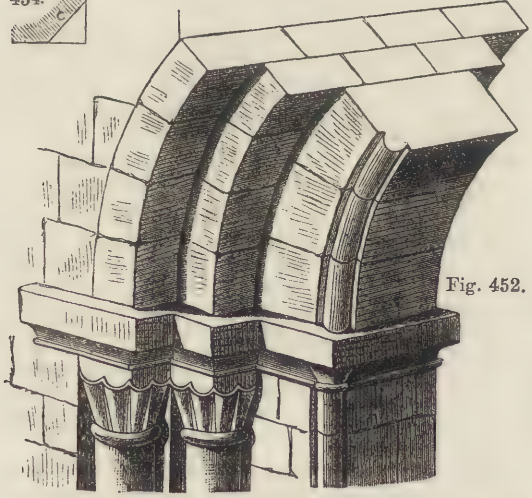


Fig. 452.

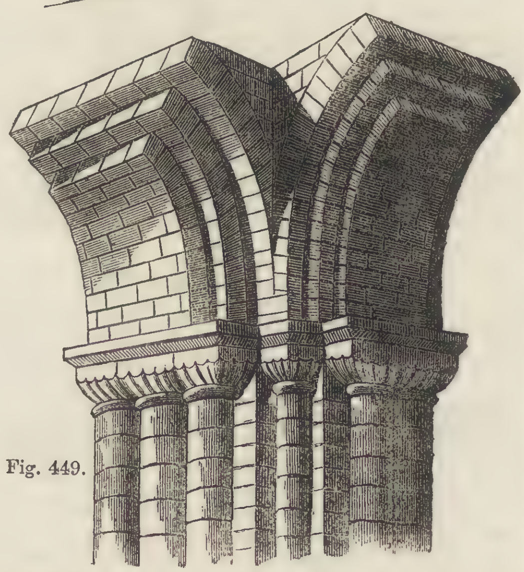


Fig. 449.

early Norman architects. They confined their ingenuity to ornamenting the flat surfaces of their arches with rude sculpture, and arches of two or more orders are constantly found, in which the entire surfaces are covered with bands of ornaments: in some, as the west door of Rochester, the entire semi-circular space (or tympanum) between the arch and the springing is filled in with sculpture.

One law, however, pervades all the Norman mouldings.

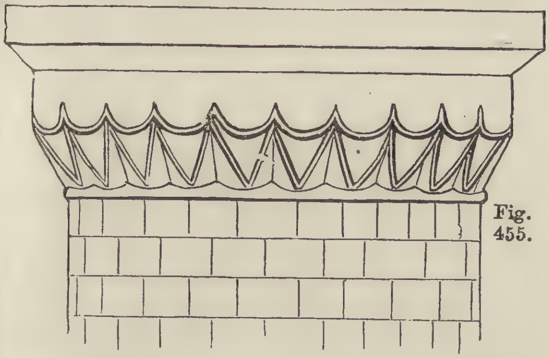


Fig. 455.

They are invariably arranged on rectangular faces, so that two lines at right angles would exactly touch the front face and under portion of the moulding.

These planes have been distinguished by Mr. Paley as the wall plane—that is, any plane, A A (Fig. 453), parallel to the main wall; the soffit plane, B, or any plane at right angles to

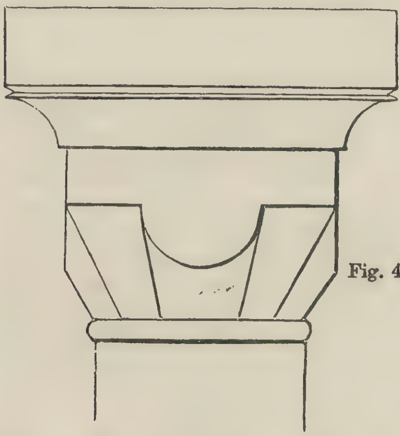


Fig. 456.

the face of the wall; and the chamfer plane, C, or such plane (Fig. 454) as is generally, but by no means invariably, placed at an angle of 45° with the two planes before mentioned.

Norman Piers.—The piers usually employed in the Norman period are of four kinds:—

1. Round, massive, columnar piers, which have sometimes a round and sometimes a square capital. They are sometimes

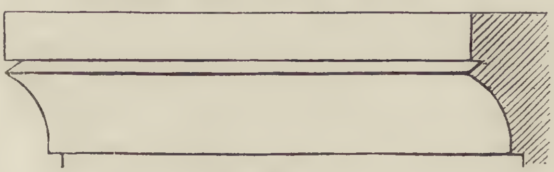


Fig. 457.

plain, and sometimes ornamented with channels in various forms; some plain zigzag, some like network, and some spiral. They are met with of various heights, from two to six, or even seven diameters.

2. Multangular. Generally octagonal, as if the pier had been originally square, and the angles chamfered off as in the case of the mouldings. These are often met in connection with arches more or less pointed.

3. Common piers with shafts. These have sometimes plain capitals, but are sometimes much ornamented with rude foliage, and occasionally animals. The shafts are mostly set in square recesses in the angles of square piers.

4. A plain pier, with perfectly plain semi-circular arches in two or three divisions.

Norman capitals are of great variety of character. Some are rude and unskilful imitations of classical examples, but the most common is the "cushion capital" (shown in Fig. 448). This is of cubical form, being rounded at the lower end to meet the shaft, the profile of the curve presenting somewhat of the appearance of the ovolo moulding. Sometimes the capital consists of many such figures of small dimensions, placed side by side (Fig. 455), the flat surface presenting a scalloped appearance, and beneath each of the scallops is a kind of inverted cone which meets the neck mould of the shaft. Some have interlaced bands and some foliage carved in slight relief, whilst others are sculptured with grotesque representations of men and animals. Fig. 455 from St. John's, Chester, and Fig. 456 from Waltham Abbey Church, Herts, are examples of the capitals alluded to.

Fig. 457 is a feature of common occurrence in Norman architecture. This is the moulding of the square abacus over the flowered or cut part of the capital. It consists of a broad fillet or hollow, separated by a sunk channel, and it is sometimes continued as a tablet along the wall.

SANITARY ENGINEERING.—XIII.

VENTILATION OF PUBLIC BUILDINGS.

In our last paper we treated of what may be called domestic ventilation, and noticed various appliances for the admission of fresh air and the exit of foul air in apartments used for ordinary residential purposes. In the present article we propose to deal with public buildings generally, and to give a few data as to the best means of obtaining efficient ventilation under all circumstances.

When a room is used for residential purposes the conditions of the atmosphere vary comparatively little, the difference between winter and summer or fire and no fire probably representing the extremes to be provided for. But in public buildings the case is very different—the audience in theatres, the congregation in churches and chapels, occupying the building perhaps for an hour or two only, and changing entirely the atmospheric position of the contents.

Perhaps there is no single building to the ventilation of which more attention has been paid than to the House of Commons. Here we have a large audience—as the members may perhaps fairly be called—occupying the building not only for an hour or two, but often for many hours in succession, sometimes almost through the night; and the warming and ventilating of what we may venture to call one of the most important of all rooms or chambers has occupied the attention of many of the first scientific men, both of this generation and some preceding it. Sir Humphry Davy made this matter the subject for a special report; the Marquis de Chabannes projected a special scheme for the purpose in the early part of the present century; while more recently it became a subject upon which Dr. Reid was especially engaged, and on which he has published an octavo volume to which we are indebted for some of our details.

The heating and ventilation of the House, as it will be readily understood, are dependent upon each other, and arrangements of the most elaborate and complicated kind were made by which they might be under the most complete control, the admission of warm air regulated by a valve under constant supervision and instant command being a leading feature in the scheme. The only departure from the general principles laid down in our previous paper was that the vitiated air, rising to the air-chamber above a glass ceiling purposely constructed, was carried first down to the ground level by a descending shaft, and then discharged through a lofty flue specially erected for the purpose at a considerable height in the air. Certain constructional conditions led to the adoption of the plan; but we cannot do better than here quote Dr. Reid's opinion (page 282 of the edition of 1844):—" That in buildings constructed originally with a view

to ventilation, it is desirable to have no *descent* of warm air." Anything approaching a detailed account of the various portions of the system is entirely beyond the limits of our present space: we may, however, quote a few of the results arrived at by actual experiments, as valuable data for parallel undertakings. A chamber was provided for moistening, drying, and cooling the air; besides the heating apparatus, arrangements were also made, by introducing the fresh air through a gauze veil, to prevent the entry of any palpable portions of soot; and every care was taken to prevent the access of offensive air from drains, from the river, or of the various sources of offence to which the peculiar situation of the House of Commons renders it so exceptionally liable. As a practical point we may note (p. 294) that the House is heated to 62° before it is opened, and maintained in general at a temperature of from 63° to 70°, according to the velocity with which the air passes through the House. Knowing the constant attention paid to the subject, the temperature of the House became a constant subject of discussion. We may imagine the difference of feeling between a weakly member, who had been sitting long in the House and had not dined, and a healthy man just come in after dining at his club. In practice the following system was adopted: all complaints on ventilation questions came gradually to be addressed to the serjeant-at-arms, who regulated the temperature by the wishes of the majority.

A similar series of difficulties has also been encountered in the ventilation of the House of Lords, and dealt with upon the same general principles.

We now propose to make a few remarks upon some of the errors most common in the ventilation of churches, chapels, and similar buildings which create the draughts that are so often a subject of complaint. A common practice is to depend upon opening a window for the admission of fresh air when the temperature rises above a certain point. What is the consequence? A column of air is admitted much colder than the body of the atmosphere of the building itself; it sinks more or less rapidly, as a natural consequence, and every person sitting within its range feels the draught. If the body of air were admitted by means of distributed openings below or at the floor level, the temperature could be regulated by a thermometer to the greatest nicety, with the certainty that the heat of the upper strata would very soon make its escape, carrying with it the deleterious remanets of respiration and combustion. Lateral ventilation, therefore, or the opening of opposite windows with a view of creating what is popularly called a thorough draught, should never be attempted in public buildings. The temperature will, of course, vary at different levels; the portion that may be taken as a guide to the whole being that occupied by the audience. In churches where there are no galleries the matter is very simple, as the section of height, if we may so describe it, which contains the pews and the pulpit, has only to be considered; and if this is kept at a comfortable temperature, it is evident that the heat of the upper portion or the cold below the floor are equally matters of indifference; but of this we may be sure, that any opening of windows, which from the necessary architectural conditions to be preserved are far above either level, will be immediately evidenced by a direct down draught. Another error, often committed, is the *unlimited* supply of air from below. As an instance, we may mention a well-known church at the West-end, which was erected within the last few years, and has been notorious for what may be called the impossibility of warming it. The warming process in this case was carried out by warm water on the principle explained in our paper, No. IX. The area of the pipes provided was barely sufficient to sustain the requisite temperature for comfort in ordinary weather, and the curious error was committed of admitting an unlimited supply of cold air into the basement of the building; the natural result followed. As soon as the air became warm by the hot-water pipes, it rose to the roof and escaped, and the openings below were so ample that it was difficult to raise the atmosphere of the body of the church many degrees above that of the external air. When there is a gallery in a church, or more than one, as is sometimes the case, the conditions then to be dealt with approach those of a theatre, where the audience occupy the whole space, as we may say, from floor to ceiling, and where, from the constant opening of doors at different levels, the balance of the air is likely to be more constantly disturbed. Who has not noticed the rush of cold air into the body of a crowded house when the doors are opened between the acts? There is very little difficulty in the warming of theatres, but much in their ventilation. It only remains to lay down the general principle that the air heated, whether by natural or artificial causes, naturally ascends, carrying with it its carbonic acid gas; and that by a proper attention to egress and ingress the temperature of a theatre can be regulated with the same nicety as that of an ordinary room. The grand motive power in all cases is the rise of the heated air; and in some cases, in dealing with theatre ventilation, it may be desirable to have exits at various levels for the benefit of different ranges of boxes, which may also be provided with fresh air in a similar way. We may notice, as a case of the recent adoption of this principle, the private boxes of Evans's, Covent Garden, each of which has its own separate open flower ventilator in the centre, communicating directly, by means of a zinc pipe, with the external air.

We have often thought that if efficient and well-considered architectural arrangements were made in the first instance, and a very moderate outlay incurred in the current expense of a small intelligent staff, whose duty it should be to regulate the temperature of the various parts of the house as circumstances might dictate, much, if not all, of the inconvenience often complained of as to the inefficient ventilation and unwholesome atmosphere of our theatres and similar buildings might be altogether obviated.

Another class of public buildings is far more readily dealt with: we allude to reading rooms and museums. In these cases artificial warmth is always required at some periods of the year in this climate, either for the comfort of the readers, or for the preservation of specimens either of natural history or similar objects from the effects of our damp atmosphere. The warming may be effected by any of the methods described in our previous papers—a most desirable result to be obtained being that the fresh air should be warmed *before* it is admitted from below, that it should gradually rise as much as possible without draught to the ceiling, and thence to the external air. It is by no means an uncommon mistake to be content with providing an exit from the ceiling into the open space within the roof: this is by no means always sufficient, as the system generally adopted now-a-days of covering roofs with felt under the slates renders them in point of fact mere hot-air chambers, from which an accidental down-draught may send down the vitiated air upon the inmates below. A shaft, and, if possible, of some considerable elevation, should always be provided at the highest point of the building for the general escape of foul air; and if the smoke flues of the building are built in conjunction but not in communication with it, their warmth will materially assist the up-draught. This point we shall not enter on further at present, as in our next paper on ventilation of hospitals we shall go into it upon a more extensive scale.

In concluding our present notice we have only space for a passing allusion to the ventilation of ships' decks, which, though not strictly within our limits, is most important and interesting to a large section of the community, as it has been well known for many years that the sleeping accommodation of a large proportion of our seamen is most deficient in this respect. The hammocks in many cases are swung between decks as near to the upper deck as may be, often above the portholes. The same results accordingly occur as we alluded to in our last paper on ill-ventilated rooms: the upper section of the air becomes thoroughly vitiated, and in case of change of watch in bad weather, men have to pass at once from this heated atmosphere, probably in a state of profuse perspiration, into the external air, which may be at a temperature below the freezing point. A careful attention to the general principles laid down above, into the mechanical details, however, of which we have not room to go, will enable all these difficulties to be obviated—if provided for in the original construction of the vessel—at comparatively moderate expense, especially in the case of steam-ships, where the heat generated by the boilers, etc., may be made available as the motive power of a most efficient system of ventilation, extending through every part of the ship.

We shall in our next paper deal with the method of ventilation of hospitals; and as we consider the subject of special importance just now, we shall endeavour to give full details of some two or three of our largest London hospitals.

NOTABLE INVENTIONS AND INVENTORS.

XXII.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS."

BY JOHN TIMBS.

EDWARD SOMERSET, sixth Earl and second Marquis of Worcester, the celebrated speculative mechanical inventor, stands almost isolated in the British peerage, but he has the superior honour of being regarded as one of the chief inventors of the steam-engine. Living in the time of the Civil War, he took part with King Charles I., who visited the Marquis several times at his castle of Raglan, the picturesque ruins of which admiring topographers to this day regard as "a romance in stone and lime." The King invested Worcester with the command of a large body of troops; but his bravery and devotedness to the royal cause failing in Ireland, he embarked for France, where he attached himself to the suite of Charles II., who then resided at the French Court, and in the following year dispatched the Marquis to London to procure private intelligence and supplies of money. He was, however, speedily discovered, and committed a close prisoner to the Tower of London. He was much attached to scientific pursuits, which accident is said to have directed in a proper course. It is related that, one day preparing some food in his apartment, the closely-fitted cover of the vessel was, by the expansion of the steam, suddenly forced off, and driven up the chimney. It then occurred to him that the same power might be applied to useful purposes; and the germ of the lesson was treasured in the first manuscript of his "Century of Inventions," which he wrote in France, but lost. He, however, re-wrote the work after his committal to the Tower, as inferred from a manuscript now in possession of the Beaufort family, which opens thus:—

"A CENTURY OF THE NAMES AND SCANTLINGS OF SUCH INVENTIONS

as at present I can call to mind to have tried and perfected, which (my former notes being lost) I have, at the instance of a powerful friend, endeavoured now, in the year 1655, to set these down in such a way as may sufficiently instruct me to put any of them in practice.

"*Artis et Naturæ proles.*"

Lord Worcester was set at liberty at the Restoration, and produced a working machine. In 1663 appeared the first edition of the "Century of Inventions;" and in the same year Parliament granted to Worcester and his successors the whole of the profits that might arise from the use of an engine described in the last article in the "Century." He likewise published his "Exact and True Definition of the Most Stupendous Water-commanding Engine," in a small quarto volume, consisting of only twenty-two pages, which is now extremely rare. His lordship survived the publication of his work but two years, as he died in retirement near London in 1667, and his remains were interred in the cemetery of the Beaufort family, in Raglan Church.

The "Water-commanding Engine" is described in the "Century" (No. 68) as "An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *infra sphæram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessel be strong enough; for I have taken a piece of the whole cannon, whereof the end was burst, and filled it three-quarters full, stopping and screwing up the broken end, as also the touch-hole; and making a constant fire under it, within twenty-four hours it burst and made a great crack; so that having found a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, have seen the water run like a constant fountain stream, forty feet high. One vessel of water, rarefied by fire, driveth up forty of cold water; and a man that tends the work has but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim, between the necessity of turning the said cocks."

We now pass on to No. 98 of the "Century:" "An engine, so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, straight, upright or downright, yet the pretended operation continueth and advanceth, none of the motions above-mentioned hindering, much less stopping, the other; but unanimously and with harmony agreeing, they all augment and contribute strength unto the intended work and operation; and therefore I call this a semi-*omnipotent engine*, and do intend that *a model thereof be buried with me.*" [Whether this intention was carried out is uncertain.]

"No. 99: How to make one pound weight to raise an hundred so high as one pound falleth, and yet the hundred pounds descending doth what nothing less than one hundred pounds can effect."

"No. 100: Upon so potent a help as these two last-mentioned inventions, a waterwork is, by many years' experience and labour, so advantageously by me contrived, that a child's force bringeth up, an hundred feet high, an incredible quantity of water, even two feet diameter. And I may boldly call it *the most stupendous work in the whole world;* not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as keep them sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions; but likewise supplying the rivers with sufficient to maintain and make navigable from town to town, and for the benefit of lands all the way it runs; with many more advantageous, and yet greater effects of profit, admiration, and consequence; so that deservedly I deem this invention to crown my labours, to reward my expenses, and make my thoughts acquiesce in way of further inventions; this making up the whole 'Century,' and preventing any further trouble to the reader for the present, meaning to leave to posterity a book wherein, under each of these heads, the means to put in execution and visible trial all and every of these inventions, with the shape and form of all things belonging to them, shall be printed by brass plates."

Mr. Partington, in his edition of the "Century of Inventions," then notes: "The last three inventions may justly be considered as the most important of the whole *Century*, and when united with the 68th article they appear to suggest nearly all the data essential to the construction of a modern steam-engine." The noble author has furnished us with what he calls a "definition" of this engine. It is exceedingly rare, as the only copy known to be extant is preserved in the British Museum. It is printed on a single sheet, without date, and appears to have been written for the purpose of procuring subscriptions in aid of a water company then about to be established:—

"A stupendous or a water-commanding engine, boundless for height or quantity, requiring no external nor even additional help or force to be set or continued in motion, but what intrinsically is afforded from its own operation, nor yet the twentieth part thereof. And this engine consisteth of the following particulars:—

"A perfect counterpoise, for what quantity soever of water.

"A perfect countervail, for what height soever it is to be brought unto.

"A *primum mobile*, commanding both height and quantity, regulator-wise.

"A vicegerent or countervail, supplying the place and performing the full force of men, wind, beast, or mill.

"A helm or stern, with bit and reins, wherewith any child may guide, order, and control the whole operation.

"A particular magazine for water, according to the intended quantity or height of water.

"An aqueduct, capable of any intended quantity or height of water.

"A place for the original fountain or river to run into, and naturally of its own accord incorporate itself with the rising water, and at the very bottom of the aqueduct, though never so big or high.

"By Divine Providence, or heavenly inspiration, this is my stupendous Water-commanding Engine, boundless for height and quantity.

"Whosoever is master of weight is master of force; whosoever is master of water is master of both; and, consequently, to him all forcible actions and atchievements are easie."

Lord Worcester's engine was exhibited in operation in the year 1656, when the Grand Duke of Tuscany visited England, at which time the marquis was a close prisoner in the Tower. It was shown at Lambeth, as thus recorded in the Grand Duke's

diary: His Highness went "beyond the Palace of the Archbishop of Canterbury to see an hydraulic machine, invented by my Lord Somerset, Marquis of Worcester. It raises water more than forty geometrical feet by the force of one man only; and in a very short space of time will draw up four vessels of water through a tube or channel not more than a span in width."

It was, until of late years, asserted by the French that Lord Worcester took the idea of his engine from De Caus, engineer to Louis XIII.; but the only evidence was a letter, written to suit an engraving originally designed to illustrate a tale of fiction, and this letter has been conclusively proved to be a forgery. Dr. Lardner has suggested that in the contrivance attributed to De Caus only one vessel was employed; whereas in Lord Worcester's contrivance steam was employed in the same manner as in the engines of the present day, being generated in one vessel, and used for mechanical purposes in another, upon which depends the whole practicability of using steam as a mechanical agent (see "Wonderful Inventions," 1868). Professor Millington has designed an engine on similar principles to those of Worcester's engine, which, with a few alterations, might be made available for the same purposes. Professor Millington's design is engraved and explained in Partington's edition of the "Century." Among the drawings in the Patents Museum at South Kensington is "No. 75. Coloured Drawing of the Marquis of Worcester's Steam-engine, 1663."

CHEMISTRY OF THE FINE ARTS.—III.

By Professor Church, Royal Agricultural College, Cirencester.

CHEMISTRY OF FIXED DRYING OILS—VOLATILE ESSENTIAL OILS—NAPHTHA, PETROLEUM, PARAFFINE—AMBER, DAMMAR, AND OTHER RESINS—VARNISHES.

In using the pigments which have been described in the two preceding lessons, it is necessary to employ some substance which will at once give coherence to the particles of colour amongst themselves, and cause them to adhere to the wall, canvas, paper, or other surface to be painted. This substance is usually a liquid or a solution, and is generally called a *vehicle* or *medium*. However, it does something more than keep the particles of pigment in their places, for it possesses a more or less complete protective power, preserving the colours used from injurious atmospheric influences. We shall first describe some of the most important materials employed in the processes of oil painting and similar methods, and amongst these the fixed drying oils claim attention in the first place.

Fixed oils are distinguished from the volatile or essential oils by the permanence of the clear stain on paper which they make. But the oils suitable for painting are not only fixed, but drying; that is, the clear stain on paper, just mentioned, becomes hard and ceases to be greasy after the lapse of a little time. This hardening is attended by the absorption of oxygen, and is known as resinification. It takes place more rapidly the purer the oil; and as the same methods of purification are applicable, to a great extent, to all the drying oils used in painting, we may devote a few words to such methods before giving a brief description of the several oils.

If a drying oil, such as linseed, be boiled alone, it thickens, becomes darker in colour, and if spread in a thin film dries more rapidly than in its original state. But the process is greatly shortened and improved by the addition of certain materials to the oil, such as white lead, litharge, black oxide of manganese, manganese sulphate, or roasted white vitriol, *i.e.*, zinc sulphate. Lead compounds have a tendency to unite with part of the oil, which consequently contains lead in solution, and as this will be darkened readily by many sulphur compounds, the use of lead compounds in the preparation of oil for pictorial use is not desirable; the dry sulphates of zinc or manganese are far preferable, and, when warmed with suitable oils, yield admirable preparations almost free from colour. Occasionally water has been used along with these sulphates. But it may be stated that where rapid drying qualities are not required so much as a pure and colourless oil free from rancidity (which betokens the presence of a free acid), then the following plan may be employed:—The oil is to be shaken up at intervals in a large bottle with twice its bulk of pure water, a little common salt or alum, and some fine white silver-sand. When the oil has separated from the aqueous liquid it is to be syphoned off, or turned into a separating funnel, and the washing process repeated on it with fresh water, sand, and salt; this must be done over and over again, until the wash-water remains clear. Finally, the oil, from which the mucilage has been now completely abstracted, is filtered through warm freshly-burnt bone-black, which removes at once moisture and the last traces of colour. Other methods of purifying oil are these:—Boil for two hours 1 gallon of oil, skim it, then add 100 grains of calcined magnesia, and boil again. Mix 3 lb. of oil with a quart of alcohol, and keep the mixture in a warm place.

The fixed drying oils, when pure, consist essentially of combinations called glycerides. These are compounds of the residue of glycerine, with the residues of about three or four different acids, such as linoleic, stearic, and palmitic. In other words, they contain glycerine, in which the three atoms of replaceable hydrogen, $C_3H_5H_3O_3$, have been replaced by the several radicles of these acids. These compounds admit of several isomeric modifications, especially under the influence of heat, and are easily decomposed into glycerine and soaps by alkalies. The drying oils may be identified by several reactions, which may be further used to detect any considerable admixture of non-drying oils with them. When, for instance, one part of red nitric acid, or of nitric acid in which mercury has been dissolved, is shaken up with twelve parts of a non-drying oil, such as olive, the whole becomes solid in an hour or two; but the presence of poppy or nut oil in traces retards this solidification, and in larger quantities prevents it. As a rule, then, we may say, that nitric peroxide does not solidify the true drying oils. Oil of vitriol gives out much more heat when shaken with these oils, than when shaken with those which do not dry.

The relative merits of the several drying oils in use are not satisfactorily determined. Linseed is, indeed, most commonly employed, especially in this country, but it is a question whether poppy and nut oils do not harden more uniformly than linseed, and without forming a surface skin or pellicle. In all cases, and with all drying oils, the cold-drawn oils are superior to those which have been extracted by heat and pressure combined, and which are found to contain abundance of mucilaginous and nitrogenous matters very injurious to the quality of the oil. Some recent methods of extracting oils by the use of solvents, such as carbon disulphide (bisulphide of carbon) and mineral turpentine, yield excellent products, which, when purified as before related, are quite fit for use in painting.

The following table gives the names, sources, specific gravity, and solidifying points of the seven best drying oils:—

NAME.	ORIGIN.	SPEC. GRAV.		SOLID. POINT.
Linseed oil	Seeds of Flax, *Linum usitatissimum*	·935	*minus*	20°C.
Nut oil	Walnut, *Juglans regia*	·929	,,	18°C.
Poppy oil	Seeds of Poppy, *Papaver somniferum*	·927	,,	18°C.
Hemp oil	Seeds of Hemp, *Cannabis sativa*	·931	,,	28°C.
Fir-seed oil	Seeds of Pine, *Pinus sylvestris*	·931	,,	30°C.
Sunflower oil	Seeds of Sunflower, *Helianthus annuus*	·925	,,	16°C.
Gold of Pleasure oil	Seeds of *Camelina sativa*	·931	,,	19°C.

Of the above oils, those of linseed, hemp, and walnut have, at the same temperature, 19° C., about the same degree of fluidity, which is only $\frac{1}{10}$ of that of pure water, while poppy oil is the least fluid of all, being represented by the number 73, if water be taken at 1000. In per-centage composition the same oil varies somewhat in the proportions of its three elements, carbon, hydrogen, and oxygen, according to the proportion of its constituent glycerides; but the usual numbers are fairly represented by the per-centages—carbon 78, hydrogen 11·5, oxygen 10·5. The fixed drying oils mingle readily with benzole, spirit of turpentine, mineral turpentine, and ether, but are only partially soluble in cold spirits of wine.

The essential oils applicable for painting are far from numerous, while those actually employed are two only, those of turpentine and spike. It may be advisable to say a few words on the distinctive characters of essential oils, before describing the preparation and properties of those with which the painter is more particularly concerned. Essential oils are all volatile when freshly prepared; indeed, their method of preparation, usually distillation, involves this. But they differ remarkably in composition, some being hydrocarbons, containing therefore nothing but carbon and hydrogen; others containing oxygen as well; and a third series containing sulphur, and sometimes

nitrogen, in addition to carbon and hydrogen. But the painter has to do only with the first series of these essential or volatile oils, which contain a hydrocarbon as their main ingredient, and which are nearly always represented by the formula, $C_{10}H_{16}$: a formula which corresponds to these per-centages:—

Carbon	88·2.
Hydrogen	11·8.

Still it will be found that a small quantity of oxygen is always present in these oils, partly because they contain along with the hydrocarbon of which they mainly consist, another substance, usually a camphor or stereoptene often having the formula $C_{10}H_{16}O$; and partly because they have a strong tendency to unite with oxygen, and to become resins. In doing so they at last become acid to test-paper, thick and viscid, and at the same time acquire a yellow or brown colour of varying intensity of tone. Further, when they become quite dry they are brittle, though possessing some degree of hardness. The absorption of oxygen then, attended as it is by the changes just mentioned, is the great drawback in the use of essential oils in painting: we shall presently see how it may be obviated. Yet it must be recollected that this tendency to absorb oxygen is not without its advantages. Turpentine which has absorbed oxygen becomes ozonised, acquiring, for a time at least, some bleaching properties. As an example of this fact, note the colour of a cork which has been some time in a turpentine bottle. Now this ozone may be transferred to the oil of the pigments used in a painting, and may serve to harden and resinify them before the pigmentary particles have had time to be injured by atmospheric influences. The use of freshly distilled spirit of turpentine, which has been shaken up in a bottle three parts full of air, repeatedly renewed, suggests itself as a way of utilising the several properties of the liquids just alluded to. Volatile oils mix readily with alcohol, especially if absolute, with ether, with petroleum, and fixed oils; while they dissolve fats and many resins. A few words only on the preparation of essential oils must suffice, while we will take, as at once characteristic and important examples of these materials, the oils of turpentine and spike lavender. In order to prepare these hydrocarbons in a state as little altered as possible, the materials which contain them are distilled with water, or with salt and water, or in a current of steam. In the case of turpentine, dry distillation is also resorted to, especially after the bulk of the oil has been driven off. Turpentine, as it exudes from pine and fir trees, or as it is obtained between May and October from incisions in their barks, is a mixture of hydrocarbons and their resinified products of oxidation. In distillation the essential oil is volatilised and condensed, while the residue becomes hard, and goes under the name of rosin or colophony; it chiefly consists of an acid resin. In the case of spike lavender oil, distillation with calcined magnesia or lime can hardly be resorted to, in order to purify the product, without entailing much loss; but oil of turpentine may be submitted to this treatment. Oil of turpentine may also be purified by agitation, in a vessel kept cold, with 5 per cent. of oil of vitriol, and the subsequent distillation of the reddish thick liquid which is thus obtained. This liquid should have been previously allowed to settle, and then decanted from any deposit. An oil is obtained in this way, called terebene by Deville, and but little prone to oxidation.

The turpentine oils of commerce are:—

NAME.	SOURCE.
English Turpentine oil	*Pinus Australis*, etc.
French " "	*P. maritima.*
German " "	*P. sylvestris*, etc.
Venetian " "	*Larix Europœa.*
Pine-cone " "	*Pinus pumilio and Abies pectinata.*

These oils differ much from one another in optical character, but chemically their divergences are but slight. They boil at 160° Cent., when purified completely from acid and resinous impurities, etc., and their specific gravity is about ·860. The oil of lavender is a foreign oil, derived from *Lavandula spica*, or spike lavender, and though inferior in odour to that from *L. vera*, our English lavender, is better adapted for painting. It is a far more powerful solvent for resins and similar substances than oil of turpentine. Other hydrocarbon oils of similar properties are those of bergamot, lemon, juniper, orange, and rosemary. It is probable that some of these oils are worthy of further trials in painting than those to which they have yet been submitted. All the oils of the lemon group are less volatile than turpentine, boiling at 175° C. instead of 160°; but their specific gravity is a little lower, about ·850 instead of ·860.

Before passing on to a brief description of the chief resins, we may here appropriately introduce a class of hydrocarbons, scarcely hitherto actually employed in painting, and yet likely to prove of very great service in the arts. We refer to the natural and artificial naphthas and petroleums, and their liquid and solid products. Mineral turpentine is the commercial name given to the "spirit," or most volatile portion of native rock oils, or of the artificial paraffines prepared from coals and shales by distillation at a low and regulated temperature. It is a mixture of hydrocarbons, very inflammable and volatile, and possessing remarkable solvent powers for resins, yet with small tendency to absorb oxygen. The four simplest of these hydrocarbons are gases at ordinary temperatures, while those which make up a good part of the mineral turpentine boil at temperatures from 30° upwards. The liquid boiling at this point is called quintane, and has the formula C_5H_{12}. The four or five next members of the series, boiling at temperatures up to about 160°, may be used as substitutes for oil of turpentine for many purposes. Here also we may allude to solid paraffine, a name given to a mixture of hydrocarbons occurring in shales, rock oils, etc., or obtained from them and from peat, lignite, coal, etc., by cautious distillation. The best paraffine for the artistic purposes to which we shall subsequently refer, has a melting-point not under 58° C., and is entirely unacted upon or reduced in weight by treatment with boiling soda solution, or warming with oil of vitriol up to 100° C. Its unalterable nature has induced the writer of these papers to employ it in mural decoration and for other artistic purposes, since the year 1859, and with the most satisfactory results. We shall describe some of the modes of using it in a subsequent lesson on the processes of painting; but we may now state that it is soluble in about three parts of hot absolute alcohol, but separates on cooling; that it may be dissolved in mineral turpentine, benzole, turpentine, oil of spike, and fixed oils; and that Young's best paraffine and Field's best ozokerit are available sources of it for our present purpose. Light coal naphtha, obtained as a by-product in the distillation of coal-gas, must be distinguished from the substances just named. It chiefly consists—when freed from carbon disulphide and heavy impurities—of hydrocarbons of the benzole series, of which the most important is perhaps the first; benzole or benzine (C_6H_6), a liquid of density ·885, freezing at 3°, and boiling at 81° C. When pure, this liquid has no disagreeable smell; commercial samples of it are greatly improved in this particular by being shaken up with 5 to 10 per cent. oil of vitriol for some days, decanted off and distilled from a water-bath in a tin can and with a properly-cooled condenser. Benzole mixes with absolute alcohol, and is an admirable solvent for many resins, oils, and similar materials, but its place may to a certain extent be supplied by the next member of its series, toluole, a hydrocarbon which, with several others, accompanies it in coal-naphtha, and boils at 111°C. The higher members of the series, xylole, etc., do not evaporate with sufficient rapidity, when used with resins, oils, and paraffines.

The resins may now engage our attention. They are essentially, in origin and composition, oxidised essential oils, containing less hydrogen than these latter, and oxygen in addition. They differ greatly in physical and chemical properties. The best are those which are most free from colour, tough, hard, and destitute of distinct acid characters. These resins, however, are usually the very kinds which it is most difficult to bring into solution, so as to form varnishes. Generally, the most soluble resins are those which are most prone to change, becoming brittle and brown in course of time. We shall arrange what we have to say about the most important resins under their several names, taken in alphabetical order.

Amber is a fossil resin, and one of the most useful and least alterable of all. One of its classic names, *berenice*, preserved in the German word for amber, *bernstein*, has originated the terms vernice, vernix, vernis, and varnish; this resin having been originally used in the preparation of a varnish, by boiling it in oil. Amber has the hardness 2·5, the specific gravity 1·065. It is insoluble in alcohol, and nearly so in most fixed and essential oils, but may be dissolved in chloroform, and in some of the

other powerful solvents which we have before alluded to. It makes an excellent varnish, the colour of which may be lessened by agitation with a small quantity of calcined magnesia.

Animé.—This name is often used for some varieties of copal resin, but it appears should be confined to the resin of the *Hymenæa Courbaril*, from the West Indies and Brazil. This is the copal or *animé tendre* of the French, and is largely employed in the manufacture of carriage varnishes. It is of specific gravity 1·03, and is soluble in hot alcohol. It is not a very hard or permanent resin.

Copal is a most valuable resin, furnished by many countries, and the produce of many trees. The different varieties of it met with in commerce are not all of equal value, but in composition they seem almost identical, generally containing in 100 parts about 80 of carbon, 10 of hydrogen, and 10 of oxygen. Copal comes from North America, East Indies, Madagascar, and Sierra Leone. Its density varies from 1·045 to 1·139, while its solubility in turpentine and oils is very slight, unless it has been previously fused, or at all events roasted. It may, however, be more easily dissolved in the presence of camphor, or at a higher temperature than that, obtainable in an open vessel. In a sealed tube, copal dissolves pretty freely in camphorated turpentine at temperatures below 200° C. The advantage of this mode of preparing copal varnish over that usually pursued, of torrefying the copal previously to heating it with the linseed oil or turpentine solvent, lies in freedom from colour and oxidised products, and in greater toughness. True copal is hard, rather variable as to colour, and as to the form of the masses in which it occurs. Pulverisation and exposure to air render it more easily soluble.

Canada balsam, from *Abies balsamea*, is a resinous turpentine, which may be dissolved in oil of turpentine to form a clear and colourless varnish. It is in great part soluble in alcohol, the solution drying, when used as a varnish, in the course of a day or two.

Dammar is chiefly obtained from Singapore, but a variety is also yielded by *Dammara Australis*, a New Zealand tree. The East Indian dammar requires to be crushed and gently dried to make a clear varnish, and will then be found to be soluble to the extent of 80 per cent. in absolute alcohol, and entirely in the liquid hydrocarbons and fixed oils. A fine colourless varnish may be made by leaving the crushed Australian dammar resin, often called "kouri" or "cowdie" gum, in contact with weak alcohol for some days, shaking the mixture occasionally, and then pouring off the liquid, which is a solution of the acid resin of the dammar. The remaining substance is the neutral resin, which when dissolved in absolute alcohol, turpentine, or other similar solvent, forms a beautiful colourless varnish, yet does not approach the best copal varnish in toughness and permanence.

Mastic, from Chios, in the Grecian Archipelago, is obtained by incisions made in a tree, the *Pistacia lentiscus*. Its density is 1·07; it occurs in the form of nearly colourless and transparent tears, and is soluble in alcohol as well as oil of turpentine, forming a rapidly-drying but alterable varnish, which becomes brittle and dark-coloured by age.

Sandarach was used almost exclusively in mediæval times as the basis for the varnish of tempera pictures, and of the vehicle of oil-painting. It is not a satisfactory resin; it is the produce of the *Thuja articulata* of Barbary. It occurs in pale yellow scales, slightly acid and soluble in great part in alcohol.

Shellac is produced in Assam, and many parts of India, from a tree called *bihar*, by the puncture of an insect, the *Coccus laccæ*. When purified it occurs in yellow or brownish scales, and is brittle, and easily soluble in many acids and alkalies. It dissolves in alcohol, fusel oil, and in 1½ parts of acetone. A white or bleached shellac is often made by bleaching 25 parts of shellac in alkaline solution, with the sodium hypochlorite from 30 parts of good chloride of lime, and then adding hydrochloric acid, exposing to the sun, and allowing the mixture to stand. Afterwards some sodium sulphite is added, and the resin finally precipitated with hydrochloric acid. Sulphurous acid is also used for the same purpose, but the only plan permissible for bleaching shellac intended for artistic purposes is filtration of its solution through animal charcoal.

We have been compelled to omit several resins and vegetable waxes from our list. Such are the various resins known as dragon's blood, and used in red varnishes and lacquers, and Chinese and Japan wax.

CIVIL ENGINEERING.—XII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

DOCKS (*continued*).

A FLOATING dock is more useful than an excavated dry dock because it can be employed *anywhere* irrespective of the nature of the bottom, whether it be sand, mud, or rock, the only condition necessary to its use being that a sufficient depth of water exists to float the ship which has to be raised, together with the dock in its submerged condition beneath the keel of the ship. In this point of view it is plain that the *shallower* the dock the better; hence, provided an ordinary closed pontoon fulfils all conditions necessary to ensure stability in equilibrium, and retain a horizontal deck, whether submerged or floating with its burden, nothing can be better as respects light draught.

The necessary condition to stability in a floating dock is that it shall have a sufficient amount of ballast at its lower portion to remain vertical under all circumstances, the ballast employed in all cases being water. The usual form of such a dock is that of a long open-ended box or half-cylinder, provision being made, however, for fixing water-tight bulkheads or ends if required. Whilst the main power of flotation lies in the lower portion of the dock, it is necessary that the raised sides should also contain an amount of flotation, and it is in the distribution of this power, by altering the position and quantity of water by means of pumps, that the dock retains a horizontal floor or deck in all conditions.

The sectional floating dry dock at the United States navy yard at Philadelphia will engage our notice in the first instance. As its name implies, it is formed of *sections*. These are nine in number, and any number can be used which may be required for the length and weight of the vessel to be raised. Each section is 148 feet long and 11 feet deep outside, but six only are 32 feet wide, the remaining three being only 30 feet wide. There are also two end floats each 26½ feet long, 20 feet wide, and 8½ feet deep, adapted to the larger sections, and two somewhat smaller for use with the smaller sections.

The tanks in the sections are of timber, the bottom and ends being of white oak, 4 inches thick; the sides and top of yellow pine, the sides 5 inches thick, the top 3½ inches thick. The planks of which they are built are from 12 to 15 inches wide. Each plank is fastened with two iron spikes 9 inches long, and $7\frac{1}{16}$ inches square, to each beam at the point of crossing.

The entire structure is throughout of timber strengthened with iron braces, and considerable ingenuity was displayed in the bracing; and the fact that these timber-built docks have not proved successful, must be attributed rather to the unsuitableness of the material than to the mode of construction. The various sections are arranged side by side, and as each section has a greater power of flotation than is needed for the corresponding length of run of any ship placed across it, an economy in pumping has been introduced by separating the various sections by means of a sliding or telescope arrangement of beams at distances varying from 6 inches to 6 feet as may be required; thus a greater length of run of ship will lie between the centres of any two adjacent sections the more they become separated, and hence each section will have a greater weight to support. For heavy vessels 3 feet is far enough to separate the sections, this being the usual distance apart at which keel-blocks are placed. Each tank except the centre one has a door at either side for facility of passing from one section to another. The tanks are carefully caulked, tarred, pitched, and made water-tight. Inside them are longitudinal and transverse truss-frames so arranged as to afford the requisite strength for raising the heaviest vessels. In Fig. 25 we show the arrangement of the timbers of one of the interior trusses.

Perpendicular to the line of keel-blocks, bilge-blockways are fastened to the deck upon which the bilge-blocks slide. These ways are fitted with teeth, into which drop iron falls hinged to the back of the blocks, by which the blocks are secured at the point of bearing. The arrangement is shown in Fig. 26. The line A B in Fig. 25 corresponds with the line A B in Fig. 26.

The tanks are graduated to feet and inches to indicate the depth of the keel-blocks below the surface of the water. Gauge-rods are fixed, showing the quantity of water pumped, and therefore the lifting power exerted by each section, and thus is obtained the weight of the vessel on the dock. The full lifting power of the dock is as follows:—

	ft.		ft.		ft.		
6 sections	105	×	32	×	11	=	6,336 tons.
3 ,,	105	×	30	×	11	=	2,970 ,,
6 end floats	26·5	×	20	×	5·5	=	500 ,,
3 ,,	24·5	×	20	×	5·5	=	231 ,,
Displacement						=	10,037 tons.
Weight of tanks and machinery						=	4,145 ,,
Lifting power						=	5,892 tons.

Horizontal shores extend from each side frame. They work upon hinges at the point of bearing on the frames, and are fitted with a sliding telescopic arrangement, so as to suit themselves to the varying widths of the vessels they have to support. These shores keep the ship in the centre of the dock until the keel and bilge blocks are brought to bear.

The pumping arrangements of each section are controlled by four engines—two of 20 horse-power each, and two of 12 horse-power each. There are three pumps at each end of each section; the shafting which conveys the power from one section to another runs in a hollow sliding shaft, and may be slid in or out as required by the relative position of the sections. Between each section is a universal joint to provide against the deflections incident to the sectional arrangement.

In connection with the sectional dock is a system of land rails brought close to the water's edge, their ends corresponding flush with similar rails on the floating sections. By means of these a vessel can, when required, be removed from the sectional dock to the shore, the sections being sunk by the introduction of ballast to an exact level with the ways on shore. Hydraulic power is employed to move a vessel on or off the ways. The ram employed has a stroke of 8 feet, the cylinder being keyed to the rail when in action. As soon as the ram has gained its full stroke, the same engines which are employed in forcing the water into the cylinder, are used to move the cylinder forward another 8 feet. The ram is capable of urging forward a ship upon the ways at the rate of 1 foot per minute, and twelve minutes are occupied between each successive stroke of 8 feet. After a vessel has been standing on the shore-ways for a few days, it requires about 25 per cent. more power to push it back to the dock than to haul it on shore. The cylinder has a bore of 15 inches, and can exert a force equivalent to 800 tons lift.

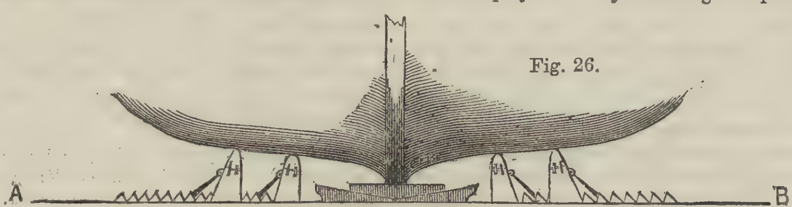


Fig. 26.

Fig. 25.

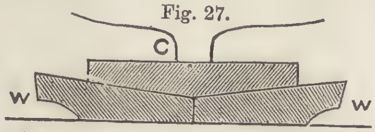
Another form of floating dock is the *balance* dock, in use in various ports of the United States. This is not merely a caisson dock, but may be described as a combination of the caisson and camel united in the form of a walled dock, having a middle compartment in which the vessel rests after the water is pumped out. The combination is made by butting the side compartments or balancing chambers—which rise considerably above the floor of the dock—with sloping inner walls, into a caisson, and giving to the structure great strength and massiveness by interwoven bracing and trussing both transversely and longitudinally. The portion of the sides extending above the windows or ports which occupy a horizontal line upon each side of the dock, is called the ballast chamber, and as the dock is almost entirely constructed of yellow pine timber, it will not sink by its own specific gravity low enough to admit vessels of great draught; it has therefore to be sunk by filling the upper or ballast chambers with water. When ships of great weight have to be lifted, it is necessary to use end or enclosing gates. These are formed of yellow pine strongly braced with iron.

To dock a vessel in the balance dock, water is forced into the bottom of the dock, and then into the upper chambers until its weight acts as ballast to sink the dock as much as required. When the ship is in the dock and in position to be raised, the ballast is run off by opening valves in the lower side chambers, thereby causing the dock to rise by its own specific gravity until it touches the bottom of the ship; the remainder of the water is then pumped out, and the dock rises with the ship. The advantage of the balance dock lies in the facility with which an exact equilibrium and level can be maintained by means of water let into or pumped out of the separate compartments of either of the side chambers, there being eight of these compartments in each side chamber, which all communicate with a pump-well in the centre of the chamber by means of valves. The advantage of dividing a floating-dock, whatever be its form, into numerous bulkheads is proved both in theory and practice, and it may be stated as a general fact that the tendency of a dock to capsize is inversely as the square of the number of separate compartments into which it is divided by bulkheads.

The necessity for examining the whole run of the keel of a ship upon the under side, and frequently of having to renew a portion, involves the necessity of removing when required any one of the keel-blocks upon which her weight rests. This was formerly a long and tedious process, the plan being to throw her weight upon the side shores by introducing wedges under each shore, the blows being given to them simultaneously. In this way the vessel was slowly raised off her keel, and the bearing transferred to the shores. The necessity for *simultaneous* action in driving home the wedges involved a very large number of men, and instances have occurred of the entire hands employed in a yard being compelled to leave their various employments in order to wield the sledge hammers for this operation. To prevent this loss of time and labour, Mr. (afterwards Sir Robert) Seppings suggested the idea of a new arrangement of keel-block. The idea is so exceedingly simple, that it is to be wondered how so obvious an arrangement had not occurred to any one connected with ship-building long before. The arrangement is shown in Figs. 27 and 28. In these C is a hard wood block having its upper and under sides lined with iron; the angle at the base is 170°. W, W are cast-iron wedges, the upper and under sides sloping to an angle of 5°. The blows for removing the wedges are given laterally as indicated by the arrows, and are delivered on alternate sides, and by this means the wedges are readily removed. Of course only one intermediate support can be removed at a time, but the wedges are easily replaced, and the next support then removed. This very simple arrangement secured for the suggester £1,000 from the Admiralty. There can be no doubt as to the superiority of iron over wood as the material for building a floating dock. Superior to it in strength, it occupies far less bulk, and is with proper care and attention far more durable. An iron dock may be considered as partaking of the same form as the ship it is intended to enclose, since the plates of which it is built can be curved to any desired shape. Looking at an iron floating dock as a semi-tube, its great weakness lies in the fact that it is unsupported by braces. It is in the connection between the inner and outer skins that a great portion of its strength lies, for although it may be regarded as one entire frame, yet like all large iron structures, especially those in which the principles of *hollow* construction are adhered to, it must be looked at from every individual point. Notwithstanding that the strength of a girder is directly as its depth, yet by an unscientific arrangement of material, it may fail locally long before the actual breaking strain is reached. There is no real difficulty in disposing of the material employed, so

that an ample amount of strength shall be secured to meet every strain in every direction, and it is due very frequently to a want of scientific knowledge in the arrangement of the material, whether employed as ties or braces, that failure ever occurs. An open-work or lattice bracing is without a doubt the proper method of obtaining the greatest strength with the least weight and expenditure of material, provided always that the various pieces composing it are properly connected. With respect to the employment of lattice-work it has very correctly been stated, that by means of it the engineer is not only enabled to place the material exactly where it is wanted—*in the very line of strain, as it were*—but he is also certain that, when it is correctly placed, the strains *must* pass in the direction marked out for them, and *cannot* take another; whereas when solid plates are used, there is always some ambiguity respecting the precise direction of the strain, and more faith is in such a case put in the mass of the plates, than in the strength of any particular part of them. We shall have occasion to call closer attention to the use and value of lattice-work when we treat of *bridges*.

Fig. 27.



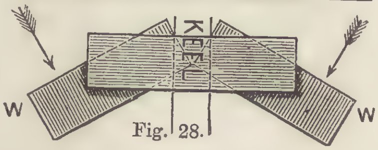


Fig. 28.

We have alluded to the value of lattice-work here, because it has been employed with great advantage in the construction of a floating dock built for Callao a few years since. It was constructed in this country in sections, and sent over and put together. In section it is rectangular, the sides being vertical, and very strongly braced at the inner angle. It is 300 feet long, 76 feet broad inside, and 30 feet deep inside, and weighs about 3,000 tons. The available floor is 50 feet wide, and the slope, which has a batter of 1·25 to 1, has a vertical height of 9 feet. There is a space of 12 feet between the inner and outer skins, in which lies the power of flotation. Water-tight bulkheads are introduced, thus diminishing the tendency to capsize. Transversely there are six water-tight bulkheads which run across the entire section, dividing the dock into seven separate transverse chambers, whilst longitudinal bulkheads, running the whole length of the dock, again subdivide these. The skins are of ½-inch boiler-plate, and there are transverse strengthening girders throughout the dock 5 feet apart, and 9 feet in depth, carried up in the form of lattice-work through the side water-compartments, air-chambers, and horizontal bulkheads.

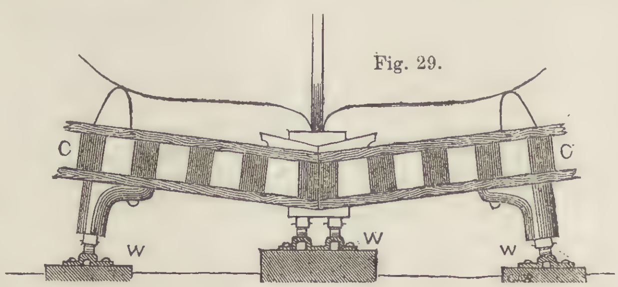
Another form of iron floating dock necessitates a brief allusion. It is that in which the inner and outer shells are semi-cylindrical. A dock of this form was constructed in the Thames some years since, and floated to Bermuda for the use of the Admiralty. Its dimensions and power are sufficient to dock the largest iron-clad. In length it is 381 feet, in outside breadth 124 feet, and in depth over all 72 feet. The space between the two skins is 20 feet. Instead of the sides being vertical, they are curved outwards with a batter of 1 in 6, but become more nearly vertical towards the top. The skins are of ½-inch boiler-plate, and the space between them is divided into fifty water-tight compartments. Seven water-tight bulkheads run throughout the entire length of the dock, whilst the frame is held together by nine transverse box-ribs also water-tight. Vertically the dock is divided into three stages, the upper chambers, the middle or balance chambers, and the lower or air chambers. In order to dock a ship, the water is pumped from the lower to the upper chambers, until the dock sinks sufficiently to permit the ship to enter at the open end, and be brought over the line of blocks. The water is then run out of the upper chambers, until the dock rises about 10 feet. Floating caissons made to fit the ends are then submerged into their position, and as much of the remainder of the water as is necessary is then run down into the air-chambers, to be again pumped up when required. In order to careen the dock for examination or repair, water is introduced into one side only, by means of which any required angle of inclination is obtained. About 8,000 tons of iron were employed in its construction.

Another system of dry-docking ships has been adopted, of value, however, in suitable localities only. In order to carry out this system, it is necessary that the ground has a certain amount of incline from the water's edge, and that a natural supply of land-water exists at the upper portion of the slope. The arrangement consists of a series of three or more basins formed in the slope, rising one above another in successive altitudes of from six to ten feet, and communicating with each other by ordinary lock-gates, similar precisely to the lock-basins of a canal. The lower basin opens directly into the harbour, and the depth over the sill must be such as that the vessel to be docked can float over it into the lower or No. 1 basin. When the vessel is within this basin, the outer gates are closed, and the land-water admitted into it until the vessel rises on a level with the water in No. 2 basin; the vessel is then floated into it, and the sluice-gates closed. The same process then follows with regard to the other basin or basins, and finally the whole of the water is withdrawn from the upper basin, and the vessel left high and dry upon the bearing blocks. The vessel is lowered to the harbour by reversing the operation.

We come now to the last method employed for dry-docking ships—that of hauling them up prepared ways by sheer force. This system was practised at an early period in the Venetian arsenals, and also at Toulon, where a large vessel was so docked as far back as 1818. The plan is adopted in many places where the ground favours it, the essential feature being that of a gradual and uniform slope both above and below the water's edge. The slope should be about 1 in 32, and the power employed may be animal, steam, or hydraulic. The arrangement consists of two parts—the *cradle* on which the ship rests, and the *ways* up which the cradle is drawn.

The cradle is a strong framing of iron and timber, furnished below with a series of small cast-iron rollers, about three or four inches in diameter, placed at short intervals apart, and ranged in three or more parallel rows, one row occupying the centre or keel line, while the others are usually placed as near the bilge-bearings as they can be. Fig. 29 gives a sketch of the cradle and ways seen in cross-section. The cradle, C C, is a strong framing, which may be extended breadth-ways as far as may be considered desirable, in order to afford sufficient space for planting shores. It must, however, be always remembered, that the cradle has to *transfer* the weight of the ship to the ways, W W, beneath, and therefore its structure must correspond with this idea. The employment of a large number of rollers is of advantage, as thereby the load is distributed over a greater number of points of support. The ways are made of timber, upon which are securely spiked iron rails. They are carried down into the water to a depth sufficient to enable a vessel to be floated over them.

Fig. 29.



Great care is required in order to obtain a solid foundation for the timber ways, piles being necessary to support them, and to prevent any subsidence into the soft ground usually found at the water's edge. When a vessel is to be docked, she is floated over the cradle, and the bow or nearest end secured in position and wedged up by the bearing blocks. The cradle is then slowly hauled up the ways by attachments at the centre and sides, and as the vessel rises she is secured in position, and the bilge-blocks driven home. Pawls are fixed at various points of the centre frame, which fall into a rack fixed to the centre way to prevent any back-fall. The power required to haul a ship and its cradle up the ways, is about ·07 of the dead weight to be moved.

PRINCIPLES OF DESIGN.—XXV.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

GLASS (*continued*).

THERE is one thing pertaining to table-glass that we do not now sufficiently consider, which is its capacity for colour. Our one idea in the formation of glass vessels is the imitation of crystal, unless we happen to produce a vessel of the strongest tint. With the exception of hock glasses, which are generally either ruby colour, dark green, or intense yellow-green, we rarely employ tinted glass on our tables. These three colours, which we usually employ in hock-glasses, are all too strong in tint for ordinary purposes, and they are coarse and vulgar. It is curious that we should confine ourselves to these colours when glass is capable of assuming the most delicate of shades, of appearing as a soft, subtle, golden hue, of the most beautiful light tertiary greens, lilacs, and blues, and, indeed, of almost any colour. Why, then, should we employ only two or three colours, and those of the most crude character?

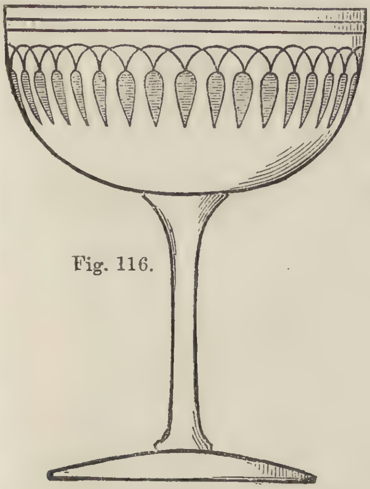


Fig. 116.

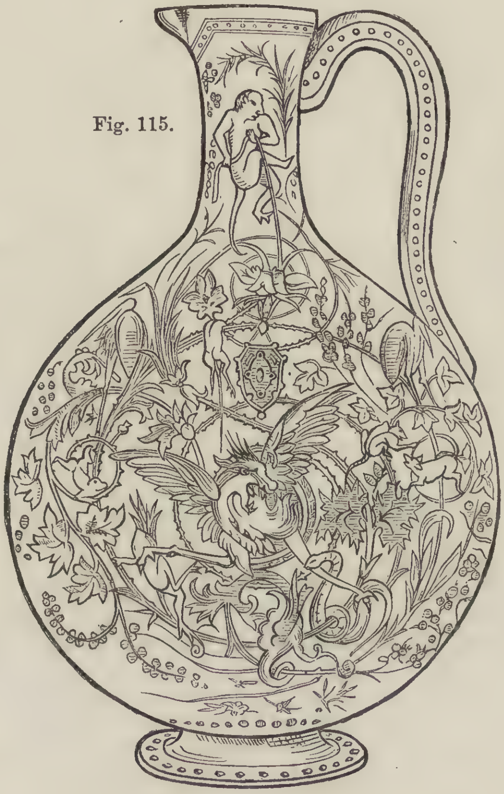


Fig. 115.

Fig. 117.

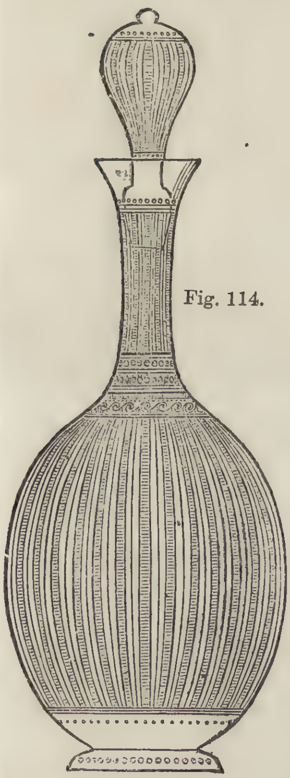


Fig. 114.

Fig. 118.

If the Roman and Greek glass of the British Museum be inspected, it will be seen that the Romans employed various soft and delicate tints, and why we should not do so likewise I cannot see. For many reasons the colours of our hock-glasses are highly objectionable, but especially for two. First, as already stated, the colour is so strong that they appear as mere dark spots on the cloth, and altogether fail in imparting to the table a pleasant colour effect; and, secondly, they utterly destroy the beauty of appearance which the wine would otherwise present.

No glass which is to contain a liquid of pleasant colour should be so strong in tint as to mar the beauty of the contained fluid, and especially is this true when the colour of the glass is of an opposite character to that of the liquid: thus a red liquid placed in a strongly-coloured green glass becomes highly offensive in appearance, and yet we often see claret served in green hock-glasses. A dinner-table requires colour. Let the cloth be pale-buff, or cream-colour, instead of white; and the glass water-vessels of very pale, but refined and various tints; and the salt-cellars, if of glass, also coloured, and a most harmonious effect could be produced. The flowers with which the table is adorned would then harmonise with the other things, and much beauty might be produced.

Respecting the ornamentation of glass, two modes of treatment are resorted to, which are "cutting" and "engraving." Both modes of treatment deal with glass as a hard, crystal-like substance; and consist in grinding the surface, and either leaving it "dead" or repolishing it. In the case of "cutting," a considerable portion of the substance of the glass is generally removed, and the surface is repolished; but in the case of "engraving" little more than the surface is generally acted upon, and the engraved portion remains dead.

Cutting may be employed in bringing about ornamental effects

in glass, but it is rarely to be commended when so lavishly used as to be the chief means of giving form to the vessel; indeed, cutting should be sparingly and judiciously used. A vessel formed of glass should never be wholly shaped by cutting, as though it were a work of stone. If the neck of a decanter can be made more convenient by being slightly cut—if it can be so treated that it can be held more securely—then let it be cut; but in all cases avoid falling into the error of too much cutting, which causes the work to appear laboured, for any work which presents the appearance of having been the result of much labour is as unpleasant to look upon as that work is pleasing which results from the exercise of momentary skill. There is a great art-principle manifested in the expression "Let there be light, and there was light."

Engraving is also laborious, and while it is capable of yielding most delicate and beautiful effects, it should yet be somewhat sparingly used, for extravagance in labour is never desirable, and there is such a thing as extravagance in beauty.

However delicate ornament may be, and however well composed, yet if it covers the whole of the walls of an apartment and of the objects which it contains, it fails to please. There must be the contrast of plain surfaces with ornamented—plain for the eye to rest upon, ornament for the mind to enjoy. In the enrichment of glass these remarks fully apply. Let there be plain surfaces as well as ornamented parts, and the effect will be more satisfying than if all be covered with ornament.

All that I said respecting the decoration of damask table-linen will apply equally to glass, considering only the different way in which the effect is produced (see Vol. II., page 312). Thus we have ornament produced only by a variation of surface. Such simple means of producing an art-effect are capable of rendering in a satisfactory manner simple treatments only, but simple patterns are capable of yielding the highest pleasure, and such patterns can be almost perfectly rendered by engraving, as shown in Figs. 114,* 115, 116, 117, 118.

Somewhat elaborate effects can be rendered in glass by very laborious engraving, whereby different depths of cutting are attained, but such work is the result of great labour, and rarely produces an effect proportionate to the toil expended upon it; and if a bottle so engraved is filled with a coloured wine, the entire beauty of its engraving is destroyed. Fig. 115 is a drawing of a most elaborately engraved bottle which was shown in the Exhibition of 1862. It represents, to a great extent, wasted labour.

It must be borne in mind that any ornament placed on a decanter, wine-glass, or tumbler, is to be seen almost wholly in perspective; and the remarks made respecting the effects of folded or waved surfaces on ornament (Vol. II., page 327), and those made in reference to the application of ornament to earthen vases (Vol. II., page 375), apply equally here.

It is not my province to enter into the various methods of manipulating glass, nor into all the classes of art-effect which glass is capable of yielding: I can only call attention to general principles, and leave the art-student to think for himself what should be the treatment of any particular object. There is a sort of crackle glass which has come into use during the last few years, and is an imitation of old Venetian work; this is in some respects pleasant in appearance, but it is somewhat uncomfortable to handle, and is difficult to keep clean; its use must therefore be limited.

In another chapter I shall have a few remarks to make upon stained glass; but as our present considerations pertain to hollow vessels chiefly, and as general principles regulate the formation of all such, whether they are formed of earthenware, glass, or metal, I think it better to pass to the consideration of silversmiths' ware, and thus continue a notice of hollow vessels, than pass to a consideration of glass windows, although they are formed of the material now under review. What we are specially considering at present is vessels of capacity, or hollow wares.

In the frontispiece to this volume the publishers of THE TECHNICAL EDUCATOR have enabled me to place before the readers of my papers on the "Principles of Design" a few studies in original ornament.

Ornament of some kind is applied to almost every article that we see around us. The papers on our walls, the carpets on our floors, the hangings at our windows, the plates from which we eat, are all covered by patterns of some kind; yet it is rare, even now when ornamentation has become general, to find anything original in ornament; and if we do meet with something new in kind it is often feeble or timid-looking, if it does not altogether fail in impressing us with the idea that the producer was a man of knowledge. Let the reader be assured that if the designer is a man of knowledge, his ornamental compositions will never fail to reveal his learning; that if he is a man of power, his works will reveal his strength of character; if he is a man of refined feelings, that his designs will manifest his tenderness of perception. In like manner, that if a man is ignorant he cannot withhold from his patterns the manifestation of his ignorance. Did not the Egyptians express their power of character in their ornaments? did not the Greeks manifest their refinement in the forms which they drew? do we not even find an expression of religious feeling strongly, yea impressively, set forth by some art-works, as by the illuminated manuscripts of the early Middle Ages? and do we not every day see the impress of the ignorant upon certain wall-papers, carpets, and other things? It is a fact, and it is necessary that we fully acknowledge it, that the knowledge of the producer is manifested by his works; and that the ignorance of the ignorant is also manifested in his works.

If ornament is produced having new characters, it is often feeble, and is generally without grace; while power is the expression of manliness, and grace of refinement. Without claiming to have made a successful effort, I put forth, in the frontispiece to this volume, four of my studies in original ornament, all of which are to me more or less satisfactory as studies in composition. I have endeavoured to secure in each an amount of energy, vigour, or the power of life, yet at the same time to avoid coarseness, or any glaring want of refinement. I have sought to combine right lines, which are expressive of power, with such curved shapes as shall, with them, produce a pleasing contrast of form, and express a certain amount of grace. In the light ornament on the citrine ground (that at the lower left-hand corner of our plate) I have endeavoured especially to secure an expression of grace in combination with that amount of energy which avoids any expression of feebleness.

In the border ornament I have introduced the arch form, as it hints at a structural "setting out" which is pleasant; and I have endeavoured to cause the composition to appear as though it rested on the lower dotted band, as this gives a feeling of security. I do not say that it is necessary that this be so: all I assert is that in some cases it gives a feeling of satisfaction.

So far as I know, the colouring is also original. The colours employed are chiefly of a tertiary character, but small masses of primary or secondary colours are employed in order to impart "life" to the composition.

I do not set these studies before my readers with the idea of showing them what original ornament should be: I only set them forth as examples of new compositions, and must leave each to clothe his own thoughts with a befitting expression of his individual original ideas.

* Fig. 114 represents a decanter made for the Prince of Wales by Messrs. Pellatt and Co., and is in good taste.

SEATS OF INDUSTRY.—XX.

LILLE.

BY WILLIAM WATT WEBSTER.

AMONG the trading and manufacturing towns of France, the ancient, prosperous, and progressive city of Lille holds a high place. Local tradition ascribes the origin of the town to Julius Cæsar, but there is no historical evidence whatever in support of this view. It is generally believed, however, that a château or castle existed at Lille during the last centuries of the Roman occupation of Belgic Gaul, and that round this stronghold the first beginnings of the town gathered. From its position in the midst of marshes, this castle was called Isla, and the town hence derived the name Lille or L'Isle, the island. No mention of Lille is to be found in the ancient chronicles previous to the time of Baudouin I., called Bras-de-fer, who in 863 caused several of his enemies to be hanged on the walls of the château. It was fortified by Baudouin IV., and captured by Henry III., Emperor of Germany, in 1054. In 1213 the city was retaken by Philippe Auguste, King of France, who reduced it to ashes. Towards the end of the thirteenth century it was again seized by Philippe le

Bel and again ceded to France, but it subsequently came into possession of the Counts of Flanders. In 1476 it passed to the house of Austria, and twenty years later it submitted along with the Netherlands to the domination of Spain, and was held by the Spaniards for about two centuries. Louis XIV. laid siege to it and captured it from the Spaniards in 1667; but during the wars of the Spanish succession, it was bombarded in 1708 by the allies, under the Duke of Marlborough and Prince Eugène, for 120 days, and compelled to capitulate. By the treaty of Utrecht in 1713, it was definitively reunited to France; but in 1792, the Austrians under Saxe Teschen fiercely bombarded it for six days, during which a great part of the town was burned; but after losing 20,000 men they were forced to retire.

Lille is situated on the canal connecting Scarpe and Lys, in a level, fertile district, 9 miles from the Belgian frontier, 62 miles south-east of Calais, and 124 miles north-north-east of Paris on the Northern Railway. It compares favourably with the generality of French towns in regard to the regularity, width, and breadth of its streets. The houses are, for the most part, built of brick; but are generally substantial and modern, though plain structures, and a portion of the town is constructed of stone, obtained from the neighbouring quarries. The quarter where the bulk of the manufacturing population resides, however, has a rather mean appearance. The town comprises about 300 streets and 32 squares. Few of the houses have more than two or three stories, and those more recently erected have areas in front. Lille is supplied with water from the river Deule, that distributes itself into the canal on which it is built, several branches of which, navigable by small vessels, circulate through the city. In former times Lille was enclosed within a narrow circle of walls, forming an irregular oval, between four and five miles in circumference, exclusive of the fortifications and of the moat by which it was surrounded. By a decree passed in 1858, the suburbs of Wazemmes, Esquermes, Moulins-Lille, and Fives were annexed to the city, and the old fortifications on the south side were demolished and reconstructed beyond the territory incorporated. This new enclosure was completed a few years ago. The old fortifications, which were rebuilt at the beginning of the seventeenth century, were enlarged and rendered almost impregnable by Vauban, the celebrated military engineer. Next to Turin, the citadel of Lille is considered the strongest in Europe, and it is the masterpiece of Vauban. The new fortifications, which consist of brick and earth, are pierced by eleven ordinary gates, by three *portes à eau*, and by a special entrance for the railway. Several of the ancient gates of the city, of which there are six, deserve mention. The most remarkable is the *Porte de Paris*, which, though it formed part of the fortifications marked for removal, has been allowed to remain. It is a triumphal arch in the Doric style, erected in 1682, surmounted by a trophy, with a figure of Victory crowning the bust of Louis XIV. The *Porte de Gand* or *de la Madeleine*, and the *Porte de Roubaix* or *de Saint Maurice*, were constructed by the Spaniards in 1617 and 1622 respectively, and are built in brick of divers colours. A number of houses built in the Spanish style, between 1640 and 1680, are still to be seen in the vicinity of the theatre, in the Rue des Manneliers, at the end of the Rue de Paris, and in other quarters in the city. The citadel, which forms an irregular pentagon, is separated from the city by promenades, planted with trees, by the canal of La Moyenne-Deule, and by an immense esplanade. At the extremity of the promenades stands a statue of General Negrier, by Marcel Bra, a sculptor who contributed largely to the adornment of Lille. In the district surrounding Lille, there are extensive beet-root plantations, and the agricultural produce includes flax, tobacco, oil-seeds, etc. The immediate neighbourhood of the city is studded with bleaching grounds and oil mills.

Lille is one of the chief seats of the cotton and linen manufactures of France. A great variety of goods are produced, including calico, cotton cloths, cotton yarn, handkerchiefs, *indiennes*, hosiery, gloves, hats, blankets, lace, tulle, table linen, linen thread, fine woollen goods, beet-root sugar, leather, paper, mineral acids, etc. There is a Government tobacco manufactory in the city, and a saltpetre refinery. It is estimated that Lille and its outskirts contain about 206,000 spindles for the spinning of flax and tow, distributed over eighty mills, employing a total of about 6,000 women. From 4,000 to 5,000 persons are engaged in the manufacture of sewing thread, which is carried on in some forty establishments. Only two workshops are devoted to the spinning of lace-thread. Woollen fabrics are made in some twenty mills. The number of spindles for spinning cotton exceeds 400,000, giving occupation to from 7,000 to 8,000 persons, and the produce represents an annual value of about 20,000,000 francs. Upwards of 110 establishments are employed in manufacturing common linen cloths, ribands, ticking, and damask; and 25 houses make canvas and packing cloth. In the making of smock-frocks or blouses about 4,000 women are employed. The manufacture of tulle and of lace has been steadily decreasing for a considerable time past in Lille, and threatens to leave the city altogether. About 1,200 persons find employment in the tobacco works, and the number of people who are engaged in the extraction and purification of oils, in dyeing, bleaching, sugar-making, brass-founding, machine-making, comb-making, rope-making, brick-making, and card-making is very large. There are in operation within the new boundaries of Lille about 260 steam-engines, besides about 50 in the vicinity, and 60 in the sugar-factories. In 1856 the population of Lille was returned at 67,775; in 1861 it was 131,827; and in "Joanne's Dictionnaire Géographique de la France," issued in 1869, it is stated at 154,749.

Lille possesses many public buildings and institutions, remarkable either in themselves or for their historical associations. The church of Notre Dame de la Treillé et Saint Pierre, begun in 1855, on the site *du Buc*, the cradle of Lille, is the largest and most beautiful ecclesiastical edifice in the city. It replaced the ancient collegiate church of St. Pierre, founded in 1066 by Baudouin of Lille, and destroyed during the Revolution. The church of St. Peter and St. Paul, at Wazemmes, is capable of containing 4,500 persons. There are many fine churches in Lille, adorned with pictures by Rubens, Van Vost, Van Dyck, Arnould de Vuez, and other famous painters, and with statues by Bra. The new Hôtel de Ville has since 1848 replaced the palace of Rihour, built by Jean Sans Peur in 1430 and inhabited by Charles V., from which it derived the name of Cour de l'Empereur. This palace was ceded by Philip IV. of Spain to the magistrates of Lille in 1660, and from that time till 1848 it was the Town Hall of the city. In the eighteenth century it was partially reconstructed after two fires. The façade of the Hôtel de Ville is in the style of the Renaissance, and is decorated with two symbolical statues by Bra, representing Lille artistic and Lille industrial. The Hall of Conclave (which contains a fine wainscot and six pictures by Arnould de Vuez) and the restored staircase are all that has been preserved of the ancient building. Two wings of the second storey of the pile are filled with a collection of paintings, embracing 149 pictures of the Italian, Flemish, and Dutch schools, including specimens of Raphael, Andrea del Sarto, Paul Veronese, Luca Giordano, Salvator Rosa, Rubens, Van Dyck, Jordaens, Sneyders, Van der Velde, etc., and about 300 paintings of the French school, including pictures by Valentin, Lebrun, Arnould de Vuez, and Wicar. A famous collection of drawings by Raphael, Michael Angelo, Poussin, Titian, Guido, Andrea del Sarto, Francia, Holbein, Callot, etc., bequeathed to the city by the painter J. B. Wicar; the public library, which comprises some 40,000 volumes and 515 MSS., many of them rare and valuable; the Museum of Natural History, and the Cabinet of Physical Objects, all find accommodation in apartments of the Hôtel de Ville. Besides, this edifice is the seat of the Tribunal of Commerce, the Council of Prud'hommes, the depôt for the *octrois*, the police office, and the residence of the chief civil and military authorities of the Department du Nord, of which Lille is the capital. The Bourse, which was begun in 1652, is a pile more remarkable for show than for taste. Built in brick and stone, it forms a square composed of separate houses, with a graceful steeple over the façade. The court is surrounded with arched arcades, supported by columns, and is adorned with a statue of Napoleon I., cast with the brass of cannons captured at Austerlitz. Among the principal remaining buildings are the Medical School and the Lyceum, and on the Grand Place stands a column commemorative of the siege of Lille in 1792, surmounted by a symbolical statue of the city by Bra. As a matter of course, Lille has suffered and will for some time feel the effects of the disaster that has befallen France, but she has not been specially unfortunate. In all probability she will soon recover her former prosperity.

MINING AND QUARRYING.—XV.

BY GEORGE GLADSTONE, F.C.S.

TIN.

SOURCE OF SUPPLY—NATURE OF ORE—STREAMING—MINING—PLAN OF MINE—MODE OF WORKING—TUTWORKERS—TRIBUTERS.

THIS metal is very limited in its geographical distribution; the principal commercial supplies come from Cornwall and Devonshire; from a district in the East Indies extending from the Malayan Peninsula to the island of Banca; and from the colony of Victoria.

On account of its comparative rarity, and the variety of useful purposes to which it is applied, tin usually commands a high price; in 1871 it sold for upwards of £130 per ton, a price, however, considerably above the ordinary figure.

The only ore of tin which is worked to any extent is the Cassiterite or stannic oxide, SnO_2, but called by the miners "tin-stone." The sulphide of tin occurs in limited districts, but it generally contains arsenic and other ingredients which are troublesome to separate, while the process of smelting the oxide, as will be seen presently, is a comparatively easy one. The oxide is, however, obtained in two very different ways—by regular mining and by streaming. As the latter is the simpler and most probably the more ancient, we will refer to it first, though the stream-works are now becoming of minor importance through exhaustion.

Fig. 1.

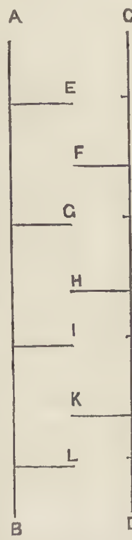


Fig. 6.

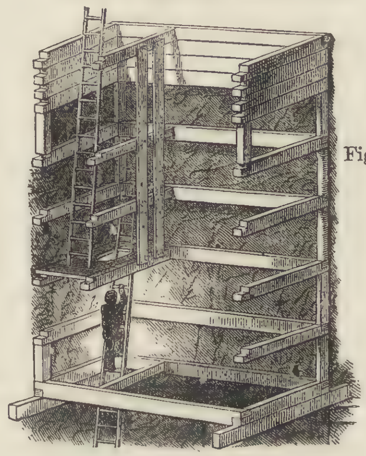


Fig. 5.

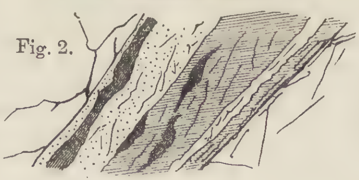


Fig. 2.

Stream tin is obtained just in the same way as gold-dust is ordinarily collected, by washing the detritus of the valleys in the district where the veins occur. The tin-stone being disseminated in small grains through the rock, becomes freed on the disintegration of the latter through the action of the weather wherever exposed to the surface; and as the ore has a very high specific gravity, varying from 5·6 to 6·9 according to its richness in metal, while the other ingredients of the granite, killas, and other rocks of the district have a specific gravity of 2·5 to 2·9 only, the tin remains behind while the lighter particles are washed away. The detrital gravels immediately overlying the rock are, therefore, generally stanniferous; and from time immemorial they have been washed to separate the ore. A great part of the surface of the southern half of Cornwall has been turned over from time to time in this search, and the few stream-works now existing are in localities which had previously been passed over on account of there being some practical difficulty in working them. Some of these have been carried by modern science under the beds of rivers, and even of inlets of the sea.

The tin-mines of Cornwall and Devonshire are generally found in those districts where the granite and other igneous rocks have forced their way up through the killas or Devonian formation, which is the prevalent rock in those counties. The granite occurs in large masses, of which there is one in Devonshire—the district of Dartmoor—and four in Cornwall; but besides these there are numerous porphyritic dykes, locally called "elvans," which ramify through all the country, but especially those parts which lie between the granitic centres; and these elvans are generally indicative of the presence of mineral veins. Taking them in the order of their importance, Truro, St. Austell, and Tavistock may be considered the centres of the mining operations. The veins which for the most part have an easterly and westerly course, often extend into the granite itself, but are generally richest about the junction of the two rocks.

In describing the mode of working a Cornish tin-mine, many of the details will equally apply to the working of copper and other ores which are disseminated in lodes or veins; so that it will be well to consider them fully now, and when treating of the other metals only to touch upon the specialities in the mining of each. Copper, indeed, is so generally prevalent in the same districts as tin, that there are few tin-mines in Cornwall in which copper ores are not also worked. Several mines which were originally opened for tinstone, became so poor in that mineral as the adventurers sunk deeper, that for a time they relied mainly on the produce of copper; some of these—Dolcoath, for instance—became in turn poorer for copper as they went still further, so as not to pay for working it, but have again become very rich in tin in depth, which is now the source of their great prosperity.

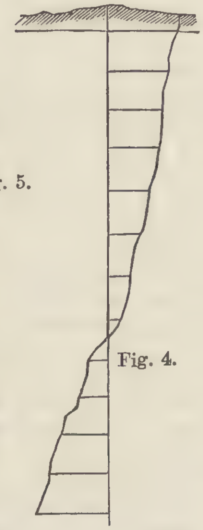


Fig. 4.

The main lode of an imaginary mine we will suppose to extend across the surface of the country in a crooked line, but having, as is usually the case, a general east and west direction, and that it dips down to an unknown depth in a southerly direction, as in Fig. 3 (see Vol. II., page 2), where A will be the north and B the south side of the diagram. Other smaller lodes may be near at hand, running somewhat parallel with this; and again another cutting through these at about right angles, which would be termed a "counter-lode." This last is probably charged with some other mineral, and throws the others out of their proper place, much in the same way as a fault disturbs the seams in a coal-mine.

The lodes are not to be understood as being full of ore, for they contain usually a variety of substances, generally more or less parallel in their arrangement, as shown in Figs. 1 and 2. In tin lodes it is not uncommon to find copper on the hanging wall, and tin-stone at the corresponding part on the opposite side or foot wall, while the intermediate space may be occupied with mundic or sulphide of iron, arsenical pyrites, wolfram, and crystallised quartz. They are, moreover, very irregular in width and in contents; three feet may be taken as an estimate of their average thickness, but they range from an inch or two to several fathoms. The dip of the lode also varies very considerably from the perpendicular, often as much as 45°, though 20° may be taken as an average dip.

The first step in opening the mine is to sink a shaft to a certain depth, not much below the surface, that may be determined to be the best level for the adit. This, whenever possible, is fixed for such a level as will cut the surface in some hollow, and so enable the water to flow from it without pumping; and just sufficient inclination is given to it to cause the water to run. This is considered the starting point of the mine, and the depth of the various levels is measured from the adit, and not from the surface, which, of course, is often very uneven.

The adit (the main drain of a mine) is marked A in the accompanying diagram (Fig. 3), which represents a section of part of the workings on the counter-lode in the celebrated Dolcoath mine; and the upper levels are seen at distances of ten fathoms apart. The cross section of the main lode is shown at the side of the diagram, and marked D D. From the adit the shaft is sunk sometimes perpendicularly, and at other times following the dip of the lode; the latter is seldom done unless the dip is very slight, as a perpendicular shaft is the most economical for working. From the shaft, when perpendicular, the levels are driven to cut the lode, either to the right or left as the case may be, as shown in Fig. 4; and then, following the course of the lode, the ore is worked out between the levels, wherever, according to the judgment of the captain, it gives promise of the best result. Those portions which have been worked out at Dolcoath are left white in the sectional drawing, and will be seen to lie principally in the neighbourhood of the great elvan course. The elvans are indicated by the letter E. The granite and killas are distinguished at both ends at once, and sometimes in the middle also, for the sake of saving time; but it requires no little nicety of calculation to secure that the several portions of the work shall meet properly.

The principle of exploring and working ore at the same time is constantly adopted in all mines; and it applies equally to opening them out laterally as well as in depth, the direction which the explorations take being generally guided by the character of the rock and the appearance of the lodes. Thus in the Dolcoath mine it will be seen that explorations have been pushed on the counter-lode far into the granite, though apparently with little success there. Had we before us a plan of the workings on the main lode, however, it would be found that some of the largest deposits of ore occur where it enters this rock.

A large quantity of timber is used underground, both as supports for the rock wherever weak, and in the shafts, as well as for tubbing wherever water occurs in quantity. Fig. 5 will illus-

Fig. 3.—SECTION OF PART OF THE WORKINGS ON THE COUNTER-LODE OF DOLCOATH TIN MINE.

by being shaded differently. The small shafts from one level to another are termed "winzes;" they are driven on the lode, partly for the sake of ventilation, and partly to afford an opportunity of seeing the character and richness of the lode for ore, which is necessary in setting the pitches, an operation to be presently described.

Tin-mines are often very wet, and it is therefore necessary so to lay out the plan of the workings that the water shall drain freely down to the pump, which is the bottom of the engine-shaft, so called because at the top of it is the pumping engine. Those used for drawing the ore to the surface are called whim-shafts. In large mines there are several of each, which are distinguished by different names, as Henriette's shaft, marked B B in Fig. 3, so named on account of its proximity to Henriette's lode marked C C. The rock through which the shafts are sunk is generally hard, and the progress made in sinking is often very slow; but a tin-mine has this advantage over a colliery, that the ore is reached near the surface, and returns may be made from the upper levels while still sinking to greater depths.

When a mine has been pretty largely developed, and it is desired to have a new shaft to communicate direct with some of the more distant workings, it is common to begin operations trate the interior construction of the shaft, and the way in which miners ascend and descend. When a mine has reached a great depth the toiling up the ladders to the surface becomes a very serious matter, especially after having completed a day's work in so warm an atmosphere as that of a deep mine. It not only occupies unprofitably a great deal of time—three-quarters of an hour or more, perhaps, in making each journey—but demands great physical exertion also, both in descending and ascending. In the best-regulated mines a man-engine is therefore substituted for the ladders, by which the time occupied is reduced to about one-fourth, and very little exertion is required. These machines were first used in Germany, and their working may be best explained by reference to the accompanying diagram (Fig. 6). A B and C D are uprights which move in the shaft vertically by turns through a space of twelve feet, so that as one ascends the other descends; E, F, G, H, etc., are platforms fixed to the uprights, upon which the miners stand. The engine being set to work, the miner has only to step from E to F when the two have arrived at the same level, and then pause a moment until he finds himself on a level with G, when he steps back to the first side. At every step, therefore, he descends twelve feet, and ascends in like manner by merely reversing the order, H to G, G to F, etc.

The labour underground is performed by two classes of men, the tutworkers and tributers. The former are those who execute work by the piece, generally calculated by the fathom. By these the shafts are sunk, the adits driven, and all other excavations made in those parts of the mine which do not produce ores. The captain of the mine having decided on certain work to be done in various parts of the workings, lets out contracts for each job to a party of tutworkers at a price mutually agreed upon, which, of course, varies very greatly according to the nature of the work, hardness of the rock, etc. During the progress of their contract they receive pay on account, a sufficient margin being left to cover contingencies, and the balance is adjusted on the completion of each job.

The tributers work only at the extraction of ore. They form themselves into parties who agree to work a portion of a lode for a given time in the best manner they can, receiving as their remuneration a certain portion of the value of the ores raised, as may be agreed upon. The captain of the mine has marked out the several pitches which he proposes to set, and the tributers have inspected them, preparatory to the setting day. At the time appointed for that purpose they all meet at the office, the captain puts up the pitches to auction, the biddings proceed downwards, and the parties of tributers who agree to take the respective pitches at the lowest rates of tribute get the contracts, provided they are not above what the captain thinks they ought to be; when such is the case they are withdrawn for another occasion. The rate per £, of course, varies according to the apparent richness of the pitch and the price of the metal at the time, as it is calculated upon the money actually realised by the ores at the periodic sales, or upon an agreed price based upon the probable course of the market. The tributers buy their coals, candles, and gunpowder from the stores belonging to the mine, at fixed prices, and pay for hauling and raising the ore to the surface, as well as the wages of those who wash and dress the ores for sale. They also receive subsistence money during the progress of their contracts, the balances being paid as soon as the amount of them can be ascertained either from the actual sales, or by calculation based upon the agreed value. The tributers have still greater elements of uncertainty to contend against than the tutworkers, but then they are occasionally rewarded with a rich find; and in the long run they realise rather better wages than the latter.

PAPER AND CARDBOARD MAKING.—III.

BY GEORGE TINDALL.

PREPARATION OF THE PULP.

The materials having been thoroughly digested by boiling in caustic liquor, until the various substances which require separation are either dissolved or thoroughly loosened from the fibrous portions, are now in a condition to be broken up and converted into pulp; but here some difference of treatment is required for the two classes of materials we have described; and, following the course we have taken in former papers, we will first describe the ordinary treatment of rags, and then point out the necessary variations in this treatment for crude vegetable fibres. The first process to which rags are subjected after boiling is a rough breaking up in a machine termed a washing-engine, during which the remaining impurities, loosened by the strong course of boiling they have undergone, are washed out, and in which the process of bleaching, if the rags are intended for white papers, is usually performed.

The washing-engine is an oblong oval vessel, usually of iron, although wood lined with lead was formerly used. This vessel is divided down the centre with an iron partition or diaphragm, which serves for regulating the course of the material, the distance from the partition to the sides of the vessel being about the same in every part; the shaft of the roll extends across the engine, and in the most improved form rests in bearings placed on movable arms on each side, which can be simultaneously raised or lowered, and is driven by a belt on one side. The roll occupies the full width between the diaphragm and one side of the engine, and is usually about two feet in diameter, divided into partitions, in which steel bars are placed, fastened down by wedges, and firmly secured by an iron hoop inserted at the end of the roll. The floor of the engine is gradually raised to the front of the roll, and then rounded to its form, and in the bottom of this circular depression is placed the bottom plate, consisting of a number of steel bars similar to those in the roll, fixed firmly together, and fitted into a frame for convenience of removal. Each of these bars has a cutting edge, and when the roll is set in motion and revolving with great rapidity, the materials are drawn into the vortex thus formed, and passing between the roll and the bottom plate, are cut into minute fragments and thrown out violently on the other side of the roll. By this means the whole mass of materials in the engine becomes involved in the current, and is carried round and successively subjected to the action of the roll till sufficiently cut to pieces. Above the engine, and capable of being elevated and lowered by suitable machinery, is the drum-washer, as it is termed—a hollow cylinder fitted with buckets or suckers inside, and covered with strong coarse-meshed wire, and outside this with fine wire gauze. When the engine is charged with rags and filled up with water from a large supply-pipe brought to each engine, the roll is set going, and as the stuff is broken up the drum-washer is lowered down into the engine, and set in motion. The dirty water is taken up and discharged from orifices in the axis of the drum, from which it is carried away by means of a waste-pipe; at the same time a copious supply of clean water is poured into the engine; and this process is continued until the water flowing away is quite clear, and the rags are thoroughly cleaned and broken into very small pieces. A fine grating at the bottom of the engine allows of the escape of heavier matters, such as will not pass through the wire gauze of the drum-washer, into a square trough, which must be regularly cleaned out.

The process of bleaching is next performed, the materials being subjected to the action of chlorine until all the colouring matter they contain is destroyed, if for white papers, and as far as is necessary for other sorts. For this purpose the bleaching-powder of commerce or chloride of lime is employed. This is dissolved in a similar pan to that used for the conversion of soda-ash into caustic soda. The bleaching-powder is put into the pan, which is then filled with water, and after being agitated for some time, the clear liquor is run off into a cistern, which should be either of stone cemented, or should be lined with lead, and the connecting-pipes should also be of lead. Two or three liquors should be taken from the same portion of bleaching-powder, and the whole run into the tank, care being taken to use it regularly of the same strength to secure uniform results. A sufficient quantity of the clear liquor is now added to the materials in the engine, the action of the drum-washer being stopped, but that of the roll continued, so that the bleaching liquor is soon thoroughly mixed with the stuff as it passes along. The addition of a little sulphuric acid causes the chlorine to be liberated more readily, and thus assists the bleaching process. When ready, a plug is drawn at the bottom of the engine, and the bleached stuff, now called half-stuff, is carried through wood pipes and emptied into large stone cisterns having a floor of perforated flat tiles, similar to those used for the floor of malting-houses; here it is allowed to stand in the liquor for some time, and afterwards the spent liquor is drained away through pipes, and sometimes pumped into a cistern, to be used over again with other materials at the close of the washing process. Care should be exercised to use the chloride of lime in as fresh a state as possible, for the chlorine is continually being evolved where it is exposed, and the buckets used for carrying it should be made of gutta-percha or of sound hard wood, metal buckets being soon destroyed by the action of the liquor.

The process is very nearly the same for crude vegetable fibres, such as straw, esparto, and wood; but for these substances a poaching-engine, as it is termed, is used. This engine is similar in all respects to the washing-engine before described, but is usually much larger, and the roll, instead of being furnished with a large number of steel bars, has a smaller quantity of wood ones. The severe treatment necessary to destroy the silica and other impurities in these materials, softens the fibre so much that they are easily broken up, and only require the fibres drawing out, whilst the effect of the steel rolls is to cut up the materials subjected to its action, instead of bruising them, as is the case in the poaching-engine. The process of bleaching is similar to that described for rags, but it is usual to bleach these materials in a hot state, by injecting steam into the engine during the operation; this assists the bleaching, and enables that process to be carried further than is possible in the cold state, and to be conducted with greater rapidity.

When the bleached material, or half-stuff, is thoroughly drained, it is thrown out of the cisterns, either into stacks or at once into boxes, and sent on to the beating-engines; but it is all the better for remaining some time—at least one whole day—in the cisterns, as the presence of free chlorine is very detrimental to the proper dyeing of the pulp.

The waste made in the manufacture of flax—a valuable material to the paper-maker, but one very full of "sheaf"—is, after being thoroughly drained in the cistern, subjected to another willowing process, called, to distinguish it from willowing unbleached materials, "white willowing." For this purpose it is put into a strong wrought-iron circular box, perforated with holes at the sides, and this is placed in a powerful hydraulic press, having a circular cast-iron block, nearly as large as the inside of the stuff box, fixed firmly to the top of the press; by this means the water contained in the half-stuff is effectually pressed out and passed through the perforated sides of the box, and the dried material passing through the willow, which revolves at an enormously high speed, is torn to small fragments, the fibres thoroughly loosened, and all foreign matters forcibly ejected in the current formed by the rapidly-revolving cone.

In the next stage, that of beating, the pulp is thoroughly prepared for the paper-machine, and here the greatest care must be exercised by the paper-maker, for upon the proper admixture and preparation of the materials in this process much of the character of the paper depends. The beating-engine is in all respects similar to the washing-engine first described, but is often larger, and the steel bars of the roll and those of the bottom plate must be regularly sharpened and kept in order, as here the stuff must be completely reduced to pulp, comminuted so fine indeed that no perceptible lumps or pieces of rag must be found in it, but every fibre drawn and separated from those with which it was before associated; here, also, the pulp must be dyed to the colour required, and, unless animal sized, that process must also be added. The engine is, in the first place, charged with the material selected, and with a copious supply of water, and the roll set in motion; here, too, a higher speed should be attained than for washing, one hundred and fifty revolutions per minute being required, and this must be kept up from three to six hours. First, a little hyposulphite of soda is added to destroy any free chlorine which may remain in the half-stuff after bleaching (this salt is usually called "antichlor" by paper-makers), and the drum-washer is also lowered, and used to wash out the resulting combination. The colouring matter is then added, ultramarine being the most commonly used for fine papers, whether white or blue; if for the former, rose-pink or some of the new magenta colours being added to give warmth of tone. Formerly the oxide of cobalt, or smalts, a very costly colour, was universally used for blue writing-papers, and for the finest hand-made papers this salt is still used; but the great improvements recently made in the manufacture of ultramarine has led to its more extensive use for the great majority of papers, and its effect is more pleasing to the eye, if not so durable as that of smalts. The agreeable yellow tone, latterly so much liked for book-printing, and even for some newspapers, is produced by the use of nitrate of iron instead of ultramarine, whilst various other salts are used, either alone or in combination, to produce the almost endless variety of colours in which paper is now made—a variety very largely increased during the past few years by the researches of chemists in the subject of coal-tar and other waste products, and the discovery of aniline, and with it of that beautiful series of colours which, for brilliancy and effect, far surpass the much-prized and, in some cases, lost colours of ancient times.

The earthy matters—such as clays and other mineral substances—are also introduced at this stage, to the great detriment of the strength of the paper, though sometimes to its advantage in appearance. In some of the lower classes of paper the percentage of mineral matters is very great, and even in good printings china clay—as the fine white clay of Devonshire and Cornwall is called—is extensively used.

Many papers are now sized in the rag-engine—indeed, all the commoner papers, as well as a large proportion of news and printings, and a few writings, are sized in this way. For this purpose rosin is boiled with somewhat less than half its weight of soda-ash, until it dissolves when beaten up in water; when cold the water is thrown off the top, and a stiff tenacious size is the result, which is stored for use, as it is much better after keeping at least a month. When used it is dissolved in boiling water, and the precaution is taken of passing it through a sieve, to keep back the impurities found in the rosin and soda-ash from which it is made. This precaution should also be taken with all the substances added during the beating of the pulp; the alum, antichlor, and also the clay, are best dissolved in water and strained through a wire sieve before they are used. Too much care cannot be taken to exclude foreign matters, especially if clean papers are being made.

Different materials vary very much in the amount of room they occupy in the beating-engine; esparto, for instance, is considerably more bulky for weight than rags, and after a little beating is considerably reduced in volume. Advantage is taken of this circumstance to introduce some other weighty substances, such as waste papers if they are used, to fill up the engines, and so increase the weight of pulp made in a given time, otherwise it is evident that more engines would be required for the manufacture of a given amount of paper from esparto than from rags; wood pulp also may be added after the volume of other materials is reduced by beating, and thus help as a filling.

When the engine is fully charged and the operation fairly commenced, the roll, which is started so as to run at some little distance from the bottom plate to allow the materials to pass easily, is by small degrees and at intervals gradually lowered, until before the operation is completed it runs in contact with the bottom plate. An ingenious piece of mechanism called a self-actor has recently been introduced, which relieves the engineer of the trouble of lowering the roll by performing that operation gradually and continuously during the process, and can be arranged to do so in a longer or shorter time, as may be necessary for different materials. This is a very useful adjunct, as it secures uniformity in beating, and guards against the carelessness of the man in charge, whose duties are then almost confined to seeing that the pulp travels regularly round the engine; as it is liable to stick in the neighbourhood of the diaphragm or at the bottom of the engine, and requires sending forward with a long flat rod, made something like an oar, so that every portion of the stuff may be subjected equally to the action of the roll.

It will not be unprofitable to compare this process of preparing pulp to that practised before the invention of the rag-engine and within the memory of some living paper-makers, when the rags, after macerating for many days in a close vessel until putrefaction set in, were beaten by means of stamping-rods shod with iron, much like the fulling-stocks not long ago used in the woollen cloth manufacture; these worked in strong oak or stone mortars, and the rags were literally almost "pounded to a jelly" in this rude apparatus. Forty pairs of these stamping-rods were required to work twenty-four hours in preparing pulp for one hundred weight of paper; now a single rag-engine will prepare pulp for three or four hundredweight of paper in four hours, and many paper-machines produce over twenty tons of paper weekly. But increased facilities for the manufacture of paper have been met by an increased demand, which is daily augmenting, and a single London daily newspaper now uses nearly one hundred tons of paper weekly, or the produce of three or four paper-machines, kept constantly running day and night, and the number of journals—daily, weekly, and monthly—is constantly increasing, so that apparently there is likely to be no lack of demand for any amount of paper that may be produced.

After the beating process has been carried on sufficiently far, which is ascertained by mixing a little of the pulp with a quantity of water, and carefully noting that no lumps are left, but that everything is reduced to minute fibres, which float about in the water, the pulp is conveyed by wooden pipes or shoots into large circular iron or wooden chests, preparatory to its final conversion into paper. Some care is required in sending down the pulp, especially if there is any sudden fall from the engines to the chests. If the plug is suddenly drawn, and the pulp allowed to rush rapidly down, the fibres sometimes mat together, forming little "knots," as they are called by the paper-maker, and these are sometimes so frequent as to give the paper quite a speckled appearance when looked through. To remedy this, the engine should be emptied gently, and plenty of water used to wash it down. This is a very common cause of the formation of "knots," though they will sometimes form in the stuff-chests, especially if the pulp is allowed to stand any considerable time before it is finally converted into paper.

TECHNICAL DRAWING.—LII.

GOTHIC STONEWORK.

NORMAN ORNAMENTS, WINDOWS, AND DOORWAYS.

Norman Ornaments.—The main feature in the Norman method of ornamentation consisted in the sculptured bands worked around the arches. These have been called *mouldings;* they are not, however, really such, but merely *decorations* of the mouldings. These ornaments are almost infinite in their variety, and all of a peculiar description. They appear in some instances to be additions carved on the originally unadorned surface of the masonry; but in most cases they were evidently worked on the block before construction. Amongst these bands, the earliest and most general is the chevron or zigzag (Fig. 458), which is frequently met with doubled, trebled, and quadrupled. The next most common on door-mouldings is the beak-head (Fig. 459), consisting of a hollow and a large round. In the hollow are placed heads of beasts or birds, whose tongues or beaks encircle the round. In the west door of Iffley Church, Oxfordshire, two whole orders are covered with these beak-heads, which extend down the entire length of the jamb down to the base moulding. We also find the alternate billet (Fig. 460), the double cone (Fig. 461), the star (Fig. 462), the square billet (Fig. 463), and the lozenge (Fig. 464). Amongst others we find the embattled, the dove-tailed, the interrupted arch, the open heart, the pointed arch, etc.

The immense number of these ornaments are here only indicated, our limits precluding further illustration of them.

The illustration (Fig. 465) is a view of the doorway of the porch of St. Mary's Church, Walmer, Kent, which, although small, is exceedingly characteristic of the style. The "outer order" is divided into three bands, which are ornamented, two with the "indented" or "trowel-point" band, the other with billets alternately broad and narrow. The indented presents the appearance of a stuccoed wall which has been pressed with a trowel-point before setting, the point being pressed deeper into the mass than the broader portion of the blade. The second order consists of a hollow and roll moulding, and the third is left unadorned. Fig. 466 is a portion of the ornamental bands enlarged.

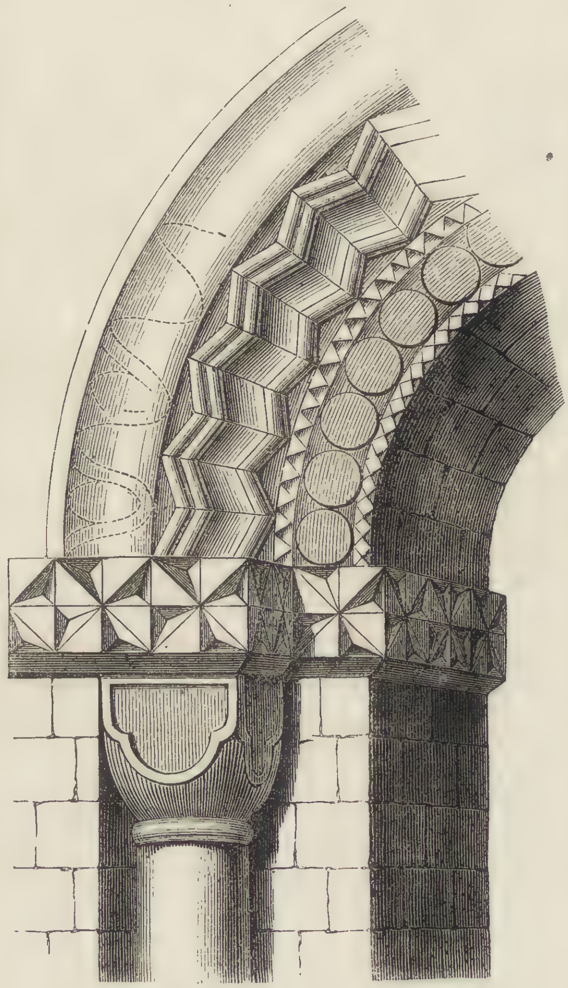


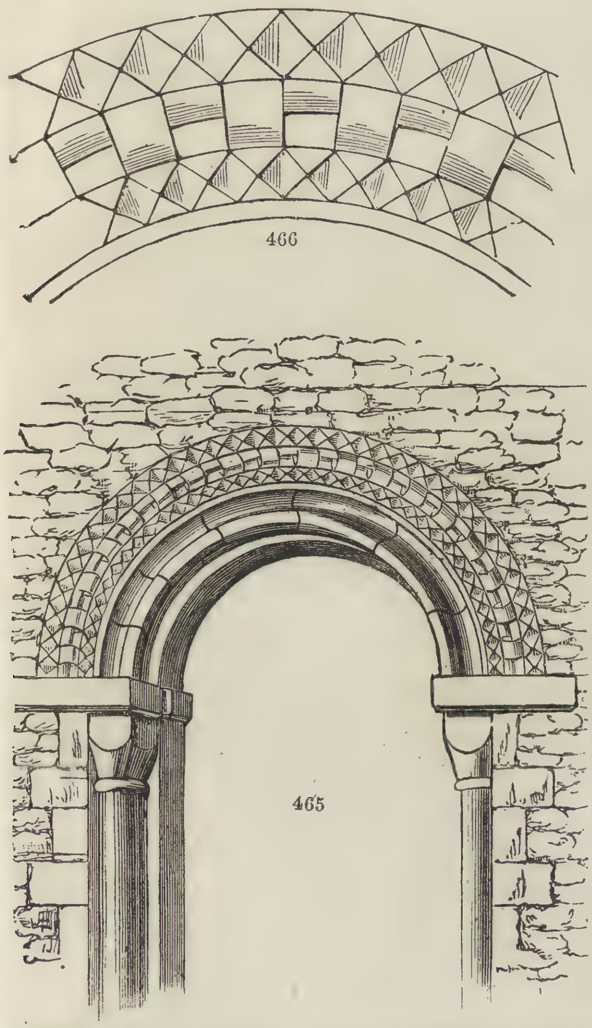
Fig. 467.

Fig. 467 gives a view of a portion of the chancel arch of the same church. In this example it will be noticed that the abacus—that is, the flat block which rests on the capitals—is continued from course to course, and round the jamb, being ornamented with a kind of diaper, formed of squares divided by lines parallel to the sides and by diagonals. The result is a star, which is worked very shallow, thus not destroying the flat character of the abacus. The capital is of the cushion character; but its height being rather greater than is usual, and the flat part being recessed in a kind of trefoil form, it has a rather elegant appearance, especially as the column is by far more slender than is common in Norman work. The outer ring of the arch has been covered with an ornamental band, which would seem to have been somewhat similar to the classic moulding called the "egg and dart." There is, however, only the barest trace of this remaining. Next follows the zigzag, and in the next order we again have three bands worked on the same ring—namely, a single indented pattern, which is merely another rendering of the zigzag, and which may perhaps have suggested the tooth ornament which forms so distinguishing a feature in the succeeding period. Next to this comes the "pellet" or stud, which consists of circular pellets placed next to each other, while the inner band is ornamented with the "trowel-point."

Norman Windows.—The windows at this period form but subordinate features in the buildings, and in earlier examples are little better than slits or narrow oblong apertures, often not exceeding a few inches in breadth, and finished with a plain semi-circular head. The glass was inserted close to the external wall, and the sides of the aperture were splayed towards the interior. The proportions of the Norman windows, as a rule, are the same as those of the doors, and very rarely exceed two squares in height, including the exterior ornaments. After a time the window-arches were enriched by the zigzag and other mouldings, and at a still later period an important improvement was made by inserting nook-shafts in the jambs, similar to those in doorways. A window of a still more advanced character is often found in the upper storeys of towers. It consists of two lights, with semi-circular heads, separated by a central shaft, and having a jamb shaft on each side. The two lights are enclosed under a larger semi-circular arch, the spandril of which, however, is rarely, if ever, pierced. Plain circular windows of small dimensions are sometimes seen in clerestories and other positions; and in churches of later date are occasionally found in gable walls larger windows of the same form, with small shafts radiating from the centre, connected at the circumference by semi-circular or trefoiled arches. There is a fine example at Barfreston, Kent.

Norman Doorways.—These are to be found in great variety, from the most simple to the most elaborate. The most simple consists of merely a semi-circular-headed aperture, with a hood-mould springing from plain square-edged jambs. The arches spring directly from an impost resting on the jambs. More frequently, however, the doorways are recessed, having a nook-shaft in the angle, formed by a recession from the capital, from which an archivolt springs, so that the arch in this case presents two soffits and two faces, besides the hood-moulds. Sometimes we have a succession of such receding arches, with a nook-shaft in each recess, from which the arches spring alternately with the projecting square-edged jambs. The depth of the doorways is owing mainly to the great thickness of the walls; but in many cases, in addition to this, that portion of the wall in which the entrance is inserted is made to project forward beyond the general face, the projection being finished above with a plain horizontal capping, or with a highly pitched gable. With this additional thickness of walling we sometimes find as many as six or eight recessions, so that the

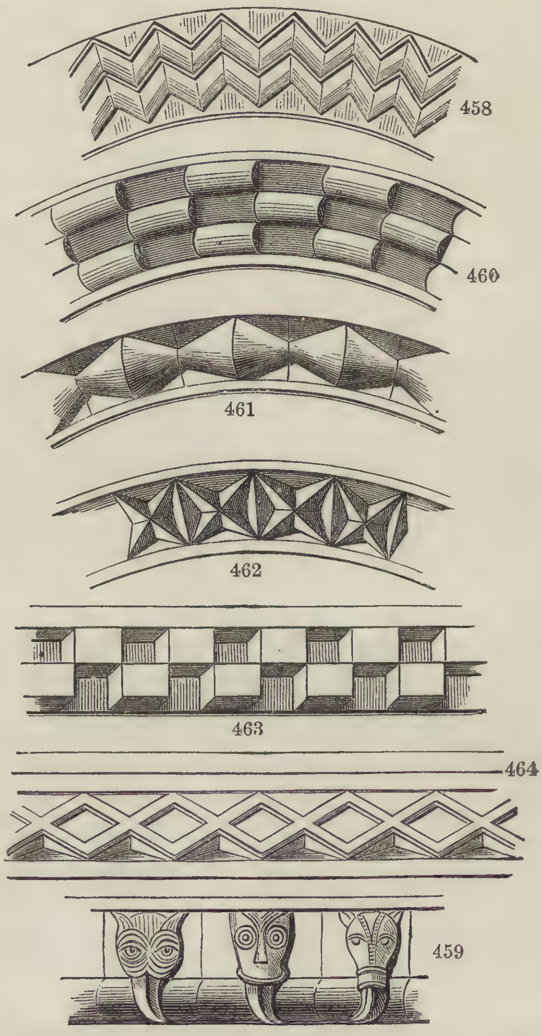
aperture of the door occupies but a very small proportion of the space when compared with the entire surface taken up by the doorway, including the dressings. The soffits and faces of the arch, as well as those of the jambs, are sometimes left plain, but are more frequently sculptured with the ornamental bands just described, and to such an extent has this kind of decoration been sometimes carried that in many instances there is scarcely a single surface left uncovered with some form of ornamentation. Even the shafts of the pillars, as already mentioned, are sometimes decorated in a similar manner, but they are more often plain, with capitals of various degrees of enrichment. Occasionally an enriched band is carried across the shaft and jambs, as if to tie them together. The aperture often follows the form of the arch, having a semi-circular head, but is very frequently square-headed, having a semi-circular tympanum of masonry to fill up the space between the lintel of the door and the intrados of the arch. This is generally enriched with sculpture, sometimes in a sort of diaper pattern of reticulated or scallop work, but more frequently representing in low relief some portion of scriptural or traditional history. The west door of Rochester Cathedral is a splendid specimen of a doorway as here described. Not unfrequently the head of the aperture is in the form of a square-headed trefoil, and sometimes of the segment of a circle of a larger radius than the external arch.



Figs. 465, 466.—DOORWAY OF THE PORCH OF ST. MARY'S CHURCH, WALMER, WITH ENLARGED PORTION OF ARCH.

A great many examples of Norman doorways still remain even in churches which present no other features of this style, for it seems to have been a frequent practice with the architects of later periods to preserve this portion of an old church even when they rebuilt the entire structure in a later style. Many of these doorways are certainly very rich and beautiful, and their preservation does credit to the taste and judgment of succeeding ages.

Semi-Norman, or Transition from Norman to Early English.—To a period somewhat earlier than the middle of the twelfth century may be ascribed the first appearance of that change in the arch which in the thirteenth and the two following centuries became generally prevalent. The arch alone, however, is no real test, for "many pure Norman works," says Mr. Rickman, "have pointed arches. The square abacus, however, may be taken as the best mark. The pointed arch, in its incipient state, exhibited a change of form only, whilst the accessories and details remained the same as before; and although this change gradually led to the Early Pointed style in a pure state, with mouldings and features altogether distinct from those of the Norman, and to the general disuse, in the thirteenth century, of the semi-circular arch, it was for a while so intermixed as, from its first appearance to the close of the twelfth century, to constitute that state of transition called the semi-Norman."



Figs. 458-464.—VARIOUS FORMS OF MOULDINGS OF THE NORMAN PERIOD.

BUILDERS' QUANTITIES AND MEASUREMENTS.—IV.

BY E. WYNDHAM TARN, M.A.

EXAMPLE OF METHOD OF TAKING OUT QUANTITIES.

We shall now illustrate the foregoing rules by taking out the quantities of a rectangular building, 30 feet by 20 feet, three storeys high, the walls in the lowest storey being 2 bricks or 18 inches thick, in the next 1½ brick, and in the top 1 brick thick; the chimney-breasts projecting 9 inches, or 1 brick in each storey, and the foundations consisting of four courses of footings, having a set-off at each course, upon a bottom of concrete 3 feet 6 inches wide, and 15 inches thick; also a cross wall of cement concrete 9 inches thick upon the bottom storey, upon 6 inches of footings 18 inches wide, with brick-nogged partitions over it on the two upper storeys. The lowest floor is taken as having a tiled floor laid upon concrete. One front is faced with malms and tuck-pointed, the other being flat-joint pointed; flat malm cutter arches over all the windows and doors:—

CONCRETE.

2)	47 0 3 6 1 3	411 3	Concrete foundations, composed of 1 of lime to 6 of ballast.
2)	8 0 9 1 3	15 0	Add.
		426 3	
	17 0 26 3	446 3	6 inch concrete floor, as above.
	15 0 1 6	22 6	6 inch Portland cement concrete, 1 of cement to 8 of ballast.
	17 0 12 6	212 6	9 inch ditto, ditto, walling, including use of apparatus.
	7 0 3 0	21 0	Ddct.
		191 6	

BRICKWORK.

2)	47 0 3	23 6	4 bk. footings.
2)	47 0 3	23 6	3½ bk. ditto.
2)	47 0 3	23 6	3 bk. ditto.
2)	47 0 3	23 6	2½ bk. ditto.
2)	47 0 12 6	1175 0	2 bk. wall.
2)	7 6 3	3 9	1 bk. footings.
2)	7 2 3	3 7	Add.
2)	6 9 3	3 5	Add.
2)	6 5 3	3 3	Add.
2)	6 0 12 6	150 0	1 bk. wall.
		164 0	
2)	4 6 4 0	36 0	2 bk. ddct.
	7 0 3 3	22 9	½ bk. ddct.
3)	6 6 3 6	68 3	Ditto.
3)	6 9 4 3	86 1	Ditto.
		177 1	
	7 3 4 0	29 0	1½ bk. ddct.
3)	9 0 4 3	114 9	1 bk. ddct.
3)	6 9 4 3	86 1	Asphalte laid on wall.
2)	47 0 10 6	987 0	1½ bk. wall.
2)	6 0 10 6	126 0	1 bk. add.
2)	3 0 3 3	19 6	1½ bk. ddct.
4)	6 6 3 6	91 0	1½ bk. ddct.
4)	8 9 4 3	148 9	Ditto.
4)	6 9 4 3	114 9	Ditto.
		354 6	
	17 4 10 6	182 0	Bk. nogged partition.
	7 0 3 0	21 0	Ddct.
		161 0	
2)	3 6 1 6	10 6	½ bk. trimmer.
2)	47 0 9 3	869 3	1 bk. wall.
2)	6 0 9 3	111 0	Add.
		980 6	
2)	2 6 3 0	15 0	Ddct.
4)	6 0 3 6	84 0	½ bk. dd
4)	6 3 4 3	106 3	Ditto.
		190 3	

	17 9 9 3	164 2	Bk. nogged partition.
	6 6 3 0	19 6	Ddct.
		144 8	
2)	3 0 1 3	7 6	½ bk. trimmer.
2)	6 0 4 6	54 0	2 bk. wall to chy. stk.

No. 6. Flues cored.
„ 6. Moulded chimney-pots.
„ 1. Kitchen range setting.
„ 5. Register stoves ditto.
„ 12. Frames bedded and pointed.
„ 8. Air-bricks.

	3 0 3 0 2 9	24 9	C. bk. wk. in copper.
	1 2 1 6 1 0	1 9	Ddct. ash-hole.
		23 0	
	30 9 29 6	907 2	Malm facing.
	6 8 2 6	16 8	Ddct.
3)	6 2 2 9	50 11	Ddct.
2)	5 8 2 9	31 2	Ddct.
		98 9	
		808 5	
	4 0 1 2	4 8	Malm cutter arch.
	3 3 5	1 4	Add soffit.
11)	4 3 1 2	54 7	Add.
11)	3 6 5	16 1	Add.
		76 8	
	9 6 7 0	66 6	1 bk. arch to cellar.
2)	6 6 7 3	94 3	1 bk. wall to ditto.
	28 0 6	14 0	1½ bk. footings.
	14 6 3 3	47 2	1 bk. wall.
	5 6 6 6	35 9	Bk. on edge, paving in sand and grouted.
	30 9 29 6	907 2	Tuck pointing.

	6 8 2 6	16 8	Ddct.
3)	6 2 2 9	50 11	Ddct.
2)	5 8 2 9	31 2	Ddct.
		1005 11	
	69 3 29 6	2042 11	Flat jt. pointing.
4)	6 2 2 9	67 10	Ddct.
2)	5 8 2 9	31 2	Ddct.
2)	15 0 4 6	135 0	Add.
		2077 11	
4)	8 9 7	20 5	Cutting to splay.
12)	94 0	1128 0	Iron hooping as bond 1½ inch × $\frac{1}{16}$ inch.
6)	7 6	45 0	W. I. chimney bar, 2½ × ½ inch.
2)	15 6	31 0	Chamfer.
2)	16 0	32 0	Double tile creasing.
	65 0 4 6	292 6	1 bk. fence wall.
	65 0 6	32 6	1½ bk. footings.
	65 0	65 0	Extra to brick on edge coping in cement.
	60 0	60 0	6 inch glazed ware socket-pipe drains, jointed in cement.

No. 3. Junctions.
„ 2. Bends.
„ 1. Syphon trap.

2)	17 0 26 3	892 6	½-in. tile paving in cement.
3)	4 3 9	9 7	Add.
	3 0 9	2 3	Add.
	4 0 1 2	4 8	Add.
		909 0	
2)	4 6 1 6	13 6	Ddct.
		895 6	
	22 6	22 6	Cutting chase for R. W. P.

SHIP-BUILDING.—IV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

COMPARATIVE FITNESS OF WOOD AND IRON FOR SHIP-BUILDING (*continued*).

We will next proceed to notice another point of interest having relation to the use of wood and iron—namely, the great contrast between the character of the *fastenings* employed. An iron ship is wholly fastened with iron rivets; the hull and its fastenings being formed of the same material. A wood ship, on the contrary, usually has iron or copper bolts for its principal fastenings, and these are obviously much harder than the wood, so that when straining forces act upon the hull the natural consequence to be looked for is a *yielding* of the softer material where it is pressed upon by its fastenings. This yielding may not be of perceptible amount in individual parts of the structure, but it is no less real, and in many instances leads to "working" in the hull. In short, as a result of the dissimilarity in character between the fastenings and the various parts of a wood ship, it is scarcely probable that the full strength of the material can ever be developed, no matter how well it may be disposed; because some amount of yielding, and consequently of "play," in the various parts is almost unavoidable. The same thing is not to be found in iron ships, for there the material is as hard as the fastenings, and the plating is no more likely to yield than the rivets are to "shear," when proper arrangements are made. As a result, it is reasonable to expect that a fuller development of the strength of the material will be obtained than is possible with wood ships.

It has been said before that wood ships usually show their weakness by hogging, and that under this condition their upper portions are subjected to tensile strains, while the lower portions are compressed. Against this compression it is easy to provide, as we shall see shortly; but for the reasons stated above it is not easy to make the longitudinal pieces and the decks efficient against severe tensile strains. Even in some of the modern wood ships of the navy, well built as they undoubtedly are, slight symptoms of weakness have been observed in the upper works; and in less carefully constructed vessels considerable changes of form are sometimes observed. It must not be overlooked that all such changes are disadvantageous, for they imply a yielding which must, in some measure, give scope for play and working in the various parts, and tend to reduce the vessel's durability as well as her strength. Recognising this fact, and desiring to prevent working in the upper parts of wood ships, some builders have for years past used iron beams for the upper decks, and fitted iron longitudinal ties upon the beams. This has proved to be a very great advantage, and has furnished further evidence of the superiority of iron to wood for ship-building purposes.

In this country wood is not easily obtainable of the sizes and forms required for ship-building, and has to be sought elsewhere; this was, as we have seen, a very serious drawback to the national industry a few years ago. When obtained, it is shaped and fashioned with considerable expense and difficulty, and it is moreover combined in a necessarily imperfect manner; besides which it is liable to many defects not easily discoverable, and often decays rapidly. On the other hand, iron is abundant with us; it can be procured readily of all the sizes and forms required, and shaped without difficulty; it admits of very superior connections and combinations; its defects are easily discovered if they exist; and its durability is greater than that of wood. No one is likely, after the experience of the last forty or fifty years, to question the greater durability of iron ships, and the only precaution needed is to prevent corrosion of the plating. Experience also has proved conclusively that iron ships may be made safer, as well as stronger, lighter, and more durable than wood ships, when they are built with proper water-tight subdivisions; and the cases which seem at first sight to go the other way, are really nothing more than examples of a faulty use of the material. Iron ships may, of course, be badly built as well as wood ships; but our point is, that when the capabilities of the two materials are each developed to the fullest extent, then iron is in all the above particulars superior to wood.

Doubts are frequently expressed as to the plating of iron ships proving sufficiently strong when they take the ground, especially on rocky bottoms, and the advocates of wood have strongly urged the superior capabilities of that material for bearing such rough usage. The fact cannot be disputed that under these exceptional circumstances the *thinness* of the bottom plating does tell against the iron ship, and that in many cases the bottoms of iron ships have been penetrated where the thick planking of a wood ship would not have been broken through, although it must have been damaged. But while admitting this, we would call attention to the fact that these circumstances are fortunately most exceptional, ships being primarily intended to keep afloat or to take the ground fairly, as any iron ship can do without danger; besides which it must be remembered that arrangements can be, and are, made in many vessels, by which the penetration of the outer plating does not admit water into the interior. The *Great Eastern*, for example, having a "double bottom" as it is termed, with two skins of iron placed two or three feet apart, kept afloat and proceeded on her voyage to New York, when a considerable portion of her outer plating had been torn away by striking on rocks off the American coast. It is true that in ordinary iron ships double bottoms are not fitted, builders and owners preferring to run the risk rather than to incur the expense; but even in these ships there are often transverse water-tight bulkheads in the hold, by means of which the spread of water entering the interior, in case of penetration, would be to some extent limited. And finally on this matter, it should not be forgotten that even when ashore and penetrated by rocks, iron ships have again and again proved themselves capable of enduring storms that would have beaten any wooden ship to pieces, and ultimately have been got off, repaired, and again made use of. The *Great Britain* furnishes a well-known example. She went ashore in Dundrum Bay, and lay on that wild coast for a whole winter; but having been got off and repaired, at a not extravagant cost, was again put into service, and is now running constantly between Liverpool and Australia. In face of evidence such as this, it is obviously improper to attach much importance to the argument against iron ships, based upon the comparatively easy penetrability of their bottoms.

The thinness of the bottom plating does, however, necessitate care on the part of the builder in order to prevent what are technically termed "buckling" and "panting"—*i.e.*, alterations of form due to the flexibility of unsupported parts. Ordinary precautions suffice to prevent any evil of this kind, and in a vessel with the frames, etc., well arranged, it need not be apprehended. It is, of course, most to be guarded against in vessels having very thin plating—for example, when steel is used instead of iron in order to save weight—but in no case need it be a matter of primary importance, or cause of great difficulty in construction. It is a matter of common observation that a thin flexible plate of iron, incapable of bearing its own weight without bending between the points where it is supported, can be made capable of bearing heavy loads by securing to it another thin plate having its depth at right angles to that of the first plate; in fact, the combination of the two forms a strong T-shaped girder. And on this principle, the plating of an iron or steel ship, although very flexible when unsupported, can be readily stiffened by a very small expenditure of material. It would be hard, if not impossible, to find a parallel case in the construction of a wood ship.

Up to the present time the capabilities of iron are far from being developed fully in ship construction, and in the majority of iron ships methods are still retained in use which were first copied from wood ships, notwithstanding that numerous examples of better methods may be found. To name one example only, the frames of iron ships will sufficiently illustrate this statement. Like those of wood ships, the frames of ordinary iron vessels were placed transversely at first, and the practice still continues. With wood, the arrangement was probably the best possible; but with iron, and especially with a skin formed of plates efficiently connected together, the case is widely different; and Mr. Scott Russell, in the *Great Eastern* and other vessels, initiated a great improvement by placing the main frames longitudinally instead of transversely, so that they could assist the skin and decks in bearing longitudinal bending strains. It cannot be denied that habit, formed by years of practice, renders it easier to build on the old plan; nor is it meant that the old plan does not answer fairly; but rather that there still remains considerable *possible* improvement to iron ships, while it is difficult to see in what particulars considerable improvements

can be made upon the existing methods of constructing wood ships. Moreover, in the immediate future it may be anticipated that the use of *steel* for ship-building will become common, and then still greater advantages than can be gained with iron may be looked for, seeing that the stronger material will be used in thinner plates and bars, and will consequently have to be combined according to what are now considered the best methods of iron ship-building, if not according to still more improved methods. Thus far the manufacture of steel does not appear to have reached that stage which enables the material produced to be regarded as in all cases thoroughly trustworthy; but this is not likely to remain so long after the demand for steel ships becomes great. Without sacrificing any of the advantages of iron, the ships built of steel will be very much lighter without being weaker, and the gap between them and wood ships will be still more remarkable than that between iron and wood ships.

The only drawback to the use of iron or steel—foulness of the bottoms of ships—will, we trust, be removed by means of some discovery ere long. It is a serious matter, no doubt; the source of much inconvenience and expense; but in spite of it iron continues to make way, and to displace wood, both in this country and abroad. Whenever vessels of extreme dimensions are required, or wherever unusual strength is needed, then or there does the ship-builder now turn to iron, and before long will turn to steel. Larger and longer ships have already been built than was thought possible a few years ago, and their use is found beneficial in every way: the men who would attempt to predict what dimensions may ultimately be reached would indeed be bold. The *Great Eastern* as yet stands quite alone, far exceeding in size any other ship; and in her construction is found sufficient evidence of the fact that in ordinary ships the capabilities of the material are far from being exhausted. Commercial considerations, not the necessities of structural strength, will in future fix the dimensions of the ships built; but if wood had continued to be the sole material in use, such a freedom of choice would not have been possible.

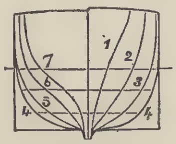


Fig. 13.

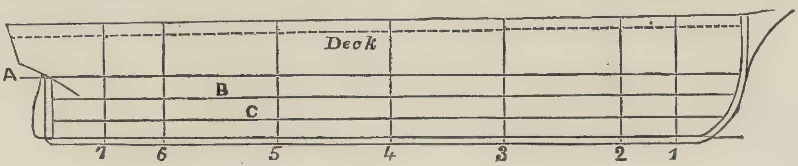


Fig. 11.

Fig. 12.

SHIP-DRAWINGS AND SPECIFICATIONS.

The design of the naval architect, when it passes into the hands of the ship-builder, is embodied in a specification and certain drawings. From the specification can be obtained particulars of the principal structural arrangements, including the details of the sizes, or scantlings, of the various parts; from the drawings may be gathered a complete knowledge of the form and dimensions of the vessel to be built, as well as of the arrangements of decks, platforms, etc., and the general requirements for stowage and accommodation. Even when thus supplied the builder has much left in his hands, and needs to exercise care in order to secure good combinations of the various parts.

This part of the work of private ship-builders is practically regulated by rules laid down by such bodies as Lloyd's Committee, and the Committee of Liverpool Underwriters, by whom registers of shipping are published, in which vessels are classed according to their character and condition, these being ascertained by surveyors acting under the direction of the committees. Lloyd's Committee is the older and better known of the two; and the phrase "A 1 at Lloyd's" has almost passed into a proverb. Underwriters are considerably guided in fixing their rates of insurance upon ships by their classification in these registers, and consequently ship-owners find it to their interest to have vessels built in accordance with the rules of the committees, in order to ensure them a high classification. It would be beside our purpose to discuss these rules here; it must suffice to state that they really furnish detailed specifications, ready made as it were, for various sizes and classes of ships; wood, iron, and composite ships being all provided for by Lloyd's Rules. The beneficial effect of these rules upon the practice of private ship-builders cannot be doubted, although some of their stipulations have caused considerable discussion, and have from time to time been modified. They represent, in fact, a great mass of information gained by experience, as well as no small amount of mechanical skill, and a fair appreciation of the science of ship-construction. With the rules before him, the builder is almost inexcusable who commits any serious mistake, and he is relieved from almost all consideration of what scantlings will be required in his ship.

In the Royal Navy the case is different, because the ships are not built to be classed, and because they are, as a rule, larger than merchant vessels, besides being designed for an entirely different service. As a consequence there are to be found many differences between the methods of construction adopted in the Royal and private dockyards, both as regards wood and iron ships, but especially the latter. It is necessary, therefore, to have a more or less detailed specification for each war-ship built, or rather for each class; and in framing such specifications regard is, of course, had to past experience as well as to present requirements. Although private builders do not conform to the practice of the Government service, they are by no means slow to admit the general superiority, in a structural sense, of the ships of the navy; but, on the other hand, they justly lay stress on the commercial aspect of the question, and prefer the cheaper vessel that answers their purpose fairly, to the better-built but more expensive vessel that they might produce, if structural considerations only had weight. This argument may, however, be pushed too far, and lead to false economy.

The drawings supplied to the builder claim but a brief notice. The principal one of the set is usually termed the "construction drawing" or "sheer draught;" and besides it there are a "midship section," "profile of inboard works," "deck plans," and "plan of hold." The sheer draught and midship section would be used at the outset by the builder, and the other drawings would come into use at further stages of the work. We will glance at them in the order named above.

The construction drawing usually consists of three plans, showing projections of various sections of the surface of the ship, and her decks, etc., upon three planes mutually at right angles—corresponding, we may say, to the "front" and "side elevations," and the "ground plan" of a house-drawing. These three plans are named respectively the "sheer," "half-breadth," and "body" plans, and are usually arranged as in Figs. 11, 12, 13. If we imagine a ship to be cut down the middle by a longitudinal plane, and the various sections of her surface, etc., to be projected upon it, we shall obtain a correct idea of the sheer plan, which gives consequently a profile view of the ship, showing her upper and lower boundaries, the stem and stern, the positions of the decks, etc. From the sheer plan, therefore, the position of any point in the ship's surface can be determined so far as *length* and *height* are concerned, as will be readily seen by referring to the outline sketch in Fig. 11.

The half-breadth plan contains the projections, upon a horizontal plane, of the various lines shown in the sheer plan; showing, for instance, the boundaries of decks, and the forms of the "water-lines"—*i.e.*, sections of the ship's surface—by horizontal planes. From this plan the position of a point can

therefore be fixed, so far as *length* and *breadth* are concerned. Only one-half of the ship is shown in this plan (see Fig. 12), as the two sides are, of course, exactly alike.

The body plan is the supplement of the other two; its plane is at right angles to both of them, and from it measurements in *height* and *breadth* can be determined. It usually consists of two parts, having a common middle line (as shown in Fig. 13), exhibiting respectively the forms of transverse vertical sections of the ship at "stations" before and abaft the midship section.

The part of the ship before the midship section is termed the "fore-body," and transverse sections belonging to it are drawn in the body plan to the *right* of the middle line. The remaining part, or "after body," has the sections belonging to it drawn to the *left* of the middle line in the body plan. These sections, it should be stated, are situated at the places where the transverse frames are placed in the ship, and the "stations" of these frames are represented by straight lines in the sheer and half-breadth plans.

The body and sheer plans are, it will be noticed, placed on the same base-line—an arrangement that is of assistance in transferring heights from one to the other. The stations 1, 2, 3 in all three plans correspond, and the transverse forms of the ship at them are shown in the body plan. The lines marked A, B, and C are what have been termed "water-lines," the true forms of which are shown in the half-breadth plan. In an actual construction draught these water-lines would, of course, be more numerous than in our sketch, and the sections in the body would also be more numerous, representing, in fact, stations only 6 or 8 feet apart. Our object being simply to illustrate the great features of the drawing, we have shown only a few examples of each. Station 4 in Figs. 11, 12 is what would be termed the midship section, and it appears in both halves of the body plan. If the vessel has more decks than one, they are shown in the sheer plan, but not usually in either of the other plans. On the sheer plan it is also customary to indicate the positions of the masts, openings in the sides of the ship, bulkheads in the hold, etc.; constituting it, as we said, an outline profile view of the ship, but omitting details that are shown on the "profile of inboard works" drawing.

By making use of all three plans it is possible to determine the true form of any section of the ship; but to do this requires a good knowledge of geometry, the twisted and curved surfaces of ships being much more difficult to deal with than the plane surfaces furnishing the ordinary problems of civil architecture and building construction. Moreover, it is obvious that for the ship-builder's purposes it is far more important to be able to determine the forms of sections of the ship when stripped of her skin, than when clothed with it; for he has first of all to fashion and fix the frames, and then to work the skin upon them. Consequently, the construction draught used by the builder is made to represent the ship's form at the *inner* surface of her skin; and although the difference between this and that at the outer surface is not great in an iron ship, it is considerable in the thicker-skinned wood or composite ship.

The drawings supplied by the designer of the ship are on a small scale, usually $\frac{1}{48}$ of the full size (or $\frac{1}{4}$-inch to a foot). For the shipbuilder's use some parts of them require to be enlarged to the full size, and this is done generally on the "mould-loft floor," the smooth plane surface of which is prepared for the purpose. The object of this process—"laying down," as it is sometimes called—is obvious—viz., to provide the means of making patterns or "moulds" of the frames and other parts of the structure. It would naturally be expected, too, that in the process of enlargement discrepancies between the three plans would become apparent which could not be detected in the small-scale drawings, and to eliminate these is a very simple matter, the technical name for which is "fairing the body." When all three plans are found to agree, the body is said to be "faired," and the process of "laying-off" has to be begun; in fact, this term is often used as including also what we have termed "laying-down." When faired, the sections in the body-plan actually represent the curves to which the frames, if transverse, must be fashioned, and at once the work of mould-making can be begun, or other means adopted for the same purpose.

The process of laying-off a ship, particularly if she be wood or composite, presents considerable difficulty, and is undertaken by a special class—the draughtsmen, who are usually practical men of superior ability, and have very responsible duties to perform. The preparation of the moulds for the various parts of a ship is in itself no light task; and in addition the draughtsman has to prepare dispositions and arrangements, under the direction of the shipbuilder, the mere enumeration of which would be tedious. It is impossible for us to give even an outline of the work done in the mould-loft; for laying-off is a subject requiring separate treatment, including as it does all the "practical geometry" of ship-building. We must therefore pass on, with the remark that its study cannot fail to benefit, both as a geometrical exercise, and as an illustration of the principles that govern the conversion of the materials used in ship-building.

Little need be said respecting the other drawings used by the ship-builder. The "midship section" gives a view of the framing of the vessel amidships, and this has a great influence on the framing throughout the length. This drawing is, in fact, almost inseparable from the construction draught, and comes into use as soon as the work on the mould-loft floor is begun. The usual practice is to lay down the midship section curve on the floor from it, before the body is faired; but it is more frequently required afterwards.

The deck plans, plan of hold, and profile of inboard works are needed to guide the ship-builder in spacing the beams and bulkheads, providing the necessary hatchways, fitting special strengthenings where required, and in many other ways while the work of building is progressing; but they are most in requisition when the "fittings" of the vessel are being proceeded with. None of these drawings, it should be remarked, are transferred to the mould-loft floor, or enlarged; they are sufficiently accurate on the small scale for all practical purposes, and measurements are taken direct from them. In building steam-ships it is also common to have drawings of the engines and boilers, showing details of the machinery, etc., and of the positions of the "bearers" that have to bear and distribute the weight.

While carrying out his work, the builder has need of many other drawings, showing details of separate parts of the structure, and prepares these for himself. For example, it is usual to prepare a detailed drawing of the framing of wood ships, to guide the men engaged in trimming the timbers; also to have what is termed an "expansion" drawing, showing the lengths and breadths of the planks or plates forming the skin, and to have similar sketches for the deck planking, besides many minor drawings. These serve a double purpose, enabling the builder to secure good combinations, and also enabling him to procure the necessary materials—for instance, from the mould-loft floor and the expansion drawings he can order all the plates for the bottom of an iron ship very nearly to their correct shapes and sizes, avoiding unnecessary waste and expense; or in case of a wood ship, he can foresee at an early stage of the work what timber will be required for conversion into bottom planking. This principle applies all through the work, the satisfactory progress of which depends very greatly upon the foresight of the builder in providing the necessary materials in good time.

It may be interesting to remark, in passing, the great differences existing between the practice of the wood and the iron ship-builder in providing their materials. The former has to procure much of his timber in the rough, and to expend considerable sums on its conversion to the forms and dimensions he requires; whereas the iron can be procured direct from the manufacturer, of nearly such forms and sizes as the ship-builder requires—no mean advantage. Many builders supplement the drawings by a model, on a small scale, of the ship to be built, and on the surface of the model draw lines showing the stations of the frames, the disposition of the outside plating or planking, the arrangements of the longitudinal pieces adjacent to the skin, etc. The practice is a very good one, and in many cases where it is followed expansion drawings are not made. In fact, such drawings are never more than approximately correct, exactitude being made impossible by the fact that the surface of a ship cannot be spread out on a plane surface—or "developed"—without cutting it into pieces; and on this account it is by no means unusual to use the model instead, as that gives a true idea of the form of the various pieces of the skin. In either case it is a wise precaution not to depend solely upon

measurements obtained from the small-scale representation of the ship, but rather to measure from the full-size sections on the mould-loft floor, whenever that can be done, as it may be in the case of the frames and beams as well as that of the skin.

OPTICAL INSTRUMENTS.—XV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

Hydrogen Generating Apparatus.—In the usual way, where house gas is attainable, it is employed to save the trouble of making hydrogen, but undoubtedly the latter (H) produces a brighter and also a more economical light than carburetted hydrogen (C_2H) when these are forced upon a lime-ball in combination with oxygen, as the combining volume of H with O is as 2 to 1, while that of C_2H with O is as 2 to 2, or equal volumes; consequently, when house gas is used more oxygen is consumed in a given time. In localities where there is a good pressure from the main, a very decent light may be obtained by connecting the jet directly with a tap soldered into the pipes that supply a house; but where the pressure is only moderate (as in some country towns), or the best light attainable is desired, then the house gas must be "run off" into a gas-bag,

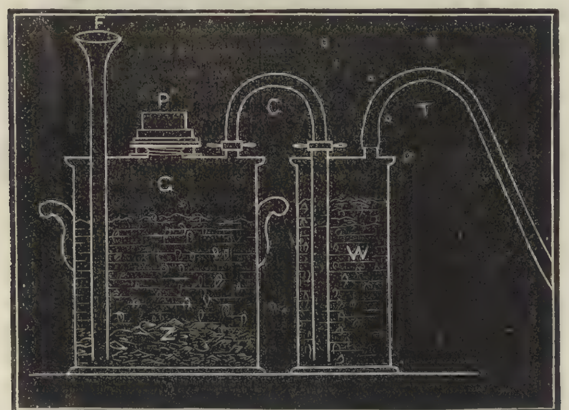


Fig. 50.

gasometer, or other receptacle that will allow of the gas being delivered at any required pressure.

Hydrogen is made by acting upon zinc with water acidulated with sulphuric acid, in which operation sulphate of zinc is formed and hydrogen is set free. The process may be conducted in a glass Woulfe's bottle, or preferably, in a generator, as shown in section in Fig. 50. This consists of a round reservoir, G, made of stout sheet lead, wherein all the seams are carefully welded. The tap is fitted with a wide gun-metal plug and washer, P, to allow of granulated zinc, or, better still, *clean* zinc cuttings, Z, being introduced and then closed up. This vessel is then filled about two-thirds full with a mixture of one part of sulphuric acid to seven parts of water, and on the action subsiding, more acid can be added through the funnel, F. The hydrogen as generated passes over by a leaden connecting-tube, C, to the dip-tube of a leaden wash-bottle, W, and after being purified by passing through the water, is carried off to the gas-bag or other receptacle by an india-rubber tube, T. We may dispense with a separate receptacle for the hydrogen gas, and deliver it direct from a leaden self-acting generator, constructed on the principle of Doebereiner's lamp. This generator is divided into two compartments connected by a tube, as shown in section in Fig. 51. The lower part is filled with sulphuric acid and water till it runs out at the stop-cock; this tap is then closed, and the acid mixture acting upon a cylinder of zinc, Z, that is supported on the outside of the connecting-tube, causes hydrogen to be generated; but the gas having no vent from the lower chamber, forces the liquid up the tube into the upper compartment. As soon as the acidulated water is driven below the zinc, the production of gas, of course, ceases. On the tap being turned, the gas is driven out with considerable force, through the pressure of the liquid descending from the upper chamber—which on coming in contact with the zinc again causes hydrogen to be given off—so that a continuous supply of gas is maintained as fast as it can be consumed by the jet, and with the necessary amount of pressure. As the gas should be washed before reaching the jet, it is better to pass it through my "interceptor" (to be afterwards described), as this not only serves as a wash-bottle, but also acts as a safety arrangement, should the hydrogen by any accident become contaminated with air, which, it must be remembered, then becomes an explosive mixture. Whatever form of hydrogen-generating apparatus is employed, a certain portion of gas should be allowed to pass away before a light is applied to the jet, or any part of the delivery-tubes, in order to provide against the accidental contamination which I have already referred to.

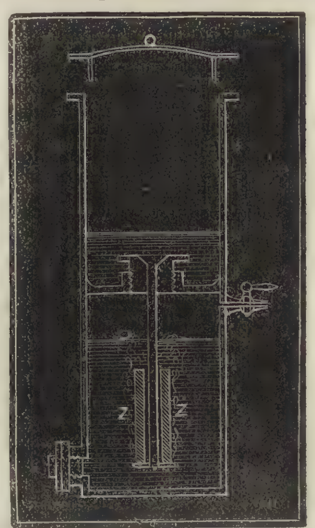


Fig. 51.

As the generator above described must be made in lead, it is, though a very convenient, a costly arrangement. One similar in principle may be cheaply made out of two large pickle-bottles, fitted with good bungs, and glass tubes arranged wash-bottle fashion, with connecting-tubes of india-rubber, as shown in Fig. 52. The zinc scraps, Z, are placed in the lower bottle, G, the sulphuric acid and water in the upper bottle, R, which is supported on a shelf in the box that contains the apparatus, and at such a height as will give the required amount of pressure. To commence operations, the acidulated water is driven into the lower vessel by blowing down the mouth-piece, M, till the liquid reaches the bung that closes G, for the purpose of driving out all atmospheric air; the tube, C, that connects the generator with the "interceptor" washing-bottle, is then closed with a stop-cock or chemical "pinch-cock." As in the former arrangement, when the gas begins to be generated, the liquid is driven up the tube, P, which provides, by its syphon action and length of tube, the required pressure. On opening the pinch or stop cock, the hydrogen is washed by passing through the water of the interceptor, I, and is carried off to the jet by the delivery-tube, D. Should an explosive mixture be found in the tubes, through inattention to equalisation of pressure, etc., in the oxygen part of the apparatus, the interceptor would completely isolate the generator, G, and the explosion would then be confined to the gas contained in the tubes.

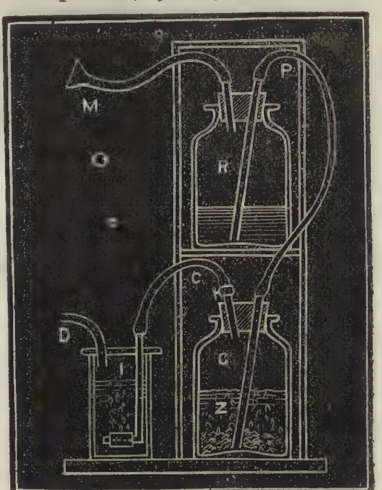


Fig. 52.

Gas-bags.—The receptacles ordinarily employed for storing oxygen and hydrogen gas for the lime-light apparatus are wedge-shaped bags made of waterproof cloth. Two qualities of this material are used; "thin" and "thick:" the former is made with jeanet, and is suited for the oxy-calcium jets, when low pressure is used; the latter is made with twill, and is requisite when the mixed gases are used under high pressure, or when the bags are

likely to be in frequent use and extra strength of material is desirable. The thin bags are cream-coloured, while the twill is usually black, but it may also be had of a light colour, and when both gases are used it is advisable to have one bag black and the other white, and to keep each of them for the same gas, independently of marking each bag H and O. It is a good plan to have the taps of the lime-light jets differently lacquered; thus the oxygen tap of the oxy-calcium jet should be bright lacquered, as it will correspond with the light colour of the thin oxygen bag. In the mixed gas jets the bright tap should again correspond with the light-coloured though stout-made bag used for the oxygen gas, but the other taps should be dark bronzed to correspond with the black bag kept constantly for the hydrogen gas. By thus methodising the arrangements, there is less chance of the gases being accidentally mixed in the bags, as would arise if they were indiscriminately used, first for one gas and then for the other. The stop-cocks fitted to the bags should have a large bore to give free passage to the gas. The taps are best made of lever-form, and so fitted in the plug that when closed the lever stands lengthways with, and not at right angles to, the stop-cock, so that not only may one know by the feel, when in the dark, whether the plug is full on or off, but it also enables us better to secure the gas when travelling by binding a string round the lever-arm and the stop-cock. The nozzle of the cock should be slightly conical, ribbed, and sufficiently long to secure a good fitting for the india-rubber tubes that are sprung on it. Before a bag is filled, it should be laid flat on the floor or table, folded smooth, the stop-cock opened, rolled up tightly, so as to drive out all air, and then the tap should be closed. It may then be connected by tubing with the generating apparatus, and when the gas is coming over properly, the cock may be opened and the bag filled, till it is as tight as a drum, when the cock must be closed, and the tube disconnected from the wash-bottle.

Pressure-boards.—When the gas-bags are required for use they are placed between two boards hinged together, out of which a semi-circular hole is cut to allow of the stop-cock projecting. On the upper board a ledge is fixed, on which the necessary weights rest. This method of arrangement is shown in Fig. 53. As such boards make a very awkward package for travelling—the smallest-sized bag suitable for an ordinary lantern exhibition should hold six cubic feet of gas, and measure about 36 inches in length by 24 inches in breadth, and 24 inches in the deep part of the wedge—I arranged the pressure-boards to fold up by means of hinges, and when opened for use to be clamped in solid shape by hinged fillets and screw-nuts, as shown in Figs. 54 and 55. The weights usually employed are, half a hundred weight on the bag used for the oxy-calcium light, and *two* half-hundred weights on *each* of the bags required for the oxy-hydrogen light. To save space, the pair of bags are sometimes laid over each other, head to tail fashion, between pressure-boards made Z shape. Mr. Malden has introduced a better arrangement, as he not only saves space, but enables the operator to dispense with half the weights required with the old system, as only two half-hundred weights are necessary to produce the same amount of pressure. The bags are placed as shown in Fig. 56, which also secures a greater quantity of pressure. The direction of slope also carries away from the stop-cocks any water that may accidentally have been blown into the bags. To prevent the bags slipping out from between the boards, a piece of sail-cloth is fastened so as to lay between the bags, which by its frictional action holds them in place with a firm grip. It will be seen that a rack is provided for the adjustment of the bags at a suitable angle.

Weights are a great drawback to the gas-bag arrangements, for 1 cwt., much more 2 cwt., form serious impedimenta in a travelling lecturer's outfit; and though weights can generally be borrowed in every town, still it does not place the operator in that position of independence from extraneous aid which is always desirable. This objection, of course, does not obtain when the apparatus is employed at a fixed residence. Various suggestions have been made for replacing the solid iron weights with other contrivances, such as bags that can be filled with sand, earth, etc., but these form bulky substitutes in the lecture-room. A more practical arrangement would be a combination of stout india-rubber springs fixed to the boards, and a racked windlass to take up the slack as the bags collapsed, but it would require frequent attention to keep the pressure tolerably equal.

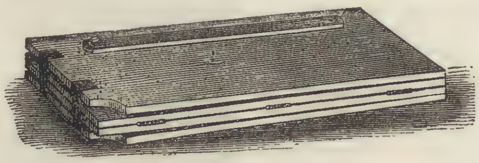


Fig. 54.

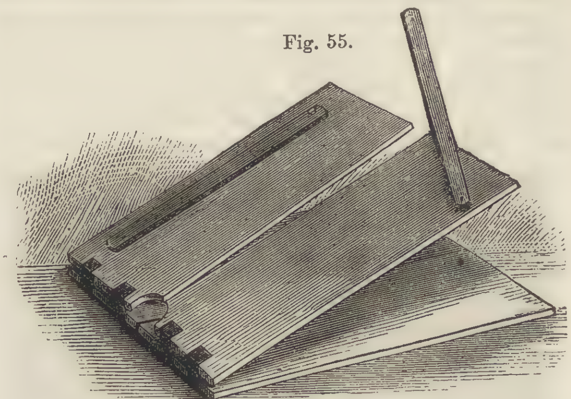


Fig. 55.

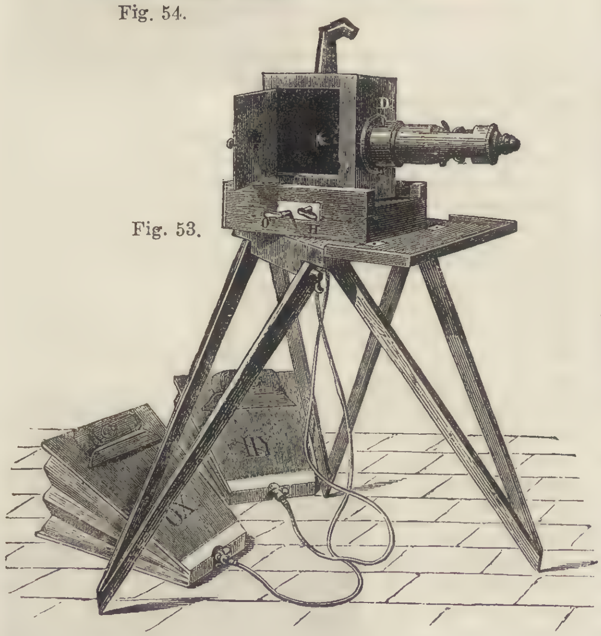


Fig. 53.

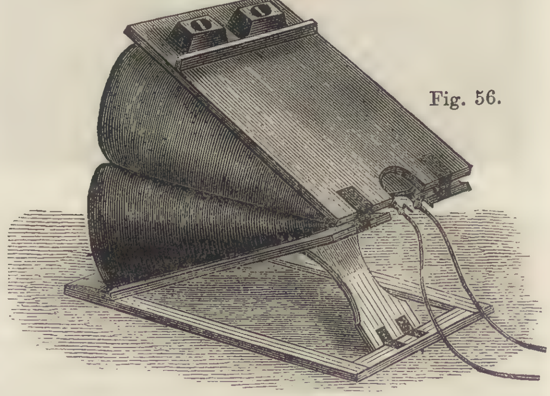


Fig. 56.

PHOTOGRAPHY.—II.

By J. C. Leake.

APPARATUS FOR PRODUCTION OF NEGATIVE PICTURES — THE CAMERA—BATH FOR SENSITISING PLATES—CHEMICALS—COLLODION — NITRATE OF SILVER — RE-DEVELOPER — METHOD OF FIXING THE IMAGE—VARNISH.

Having in our first chapter described the preparation of the photographic laboratory, or dark room, we now proceed to the description of the apparatus necessary for the production of negative pictures. By far the most important piece of apparatus for this purpose is the camera, of which we gave a brief description in our first outline of the collodion process. Cameras are made of every size and quality, and of various materials—those which are intended for studio work, where weight is no importance, being mostly constructed of wood; while those for field work and travelling are generally so made as to be light and portable, having bodies of a flexible material, impervious to light, supported by wooden framework. Although these latter are very convenient in travelling, for real hard work and certainty of action the old rigid wooden sliding-box cameras are much to be preferred, as the loose parts and intricate arrangements are very liable to get out of order, and so hinder or spoil the work. We should, therefore, advise the use of a camera of the required size constructed of mahogany, and if very much work is to be executed, a few shillings extra will be well expended in having every part of it clamped with brass. With respect to size very little can here be said, as of course this will depend upon the scale upon which the pictures are to be executed. It is well, however, for the tyro to commence operations upon moderate-sized plates, say about 8 by 6 inches, a size which, while it will prevent him from getting into a weak style of work, will, at the same time, be easily manageable. When a camera is purchased, it should be carefully examined in a strong light, in order to ascertain that there are no holes through which light may be admitted to the interior. This precaution will often save many failures. The next requisite is a lens, the selection of which will depend upon what kind of work is to be executed. Lenses for photographic purposes may be roughly divided into two classes—namely, single and combined; the former of these being generally used for landscape, and the latter for portrait work, or subjects requiring great rapidity of exposure. For ordinary landscape work, the single lens will in most cases be found sufficient; but for architectural purposes, and those in which great accuracy of delineation is required, the various combinations must be selected according to the requirements of the work. For portraiture, a double combination must be employed, which will combine a large aperture with good definition and great rapidity of action. It is perfectly useless to attempt to use one lens for many kinds of work. It is true that a lens will often answer for two or more purposes, but it is far better to employ each for the purpose for which it has been specially constructed. At the outset we should advise the purchase of two lenses—one double combination, for portraits and rapid work; and one really good single landscape lens, for copying and ordinary out-door work. Of course, we cannot here recommend any particular maker; but we may caution the purchaser against buying lenses of any but the very first quality. It is true that a good lens is expensive, but it is also most true that a really good one is absolutely necessary, and that one of inferior quality will in the end cost more than the best. The best plan for the amateur will be to consult some respectable optician as to his requirements, and be guided by his decision.

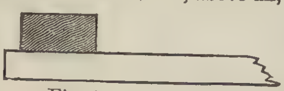


Fig. 3.

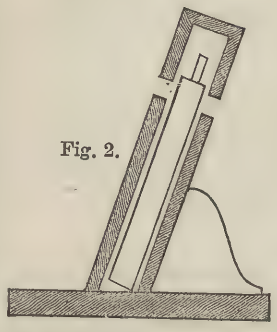


Fig. 2.

For the support of the camera, a suitable stand will be required, and, as in the case of the camera, the stands are made of different construction, according to the purposes to which they are applied; those for use in the field being light and portable, while those for the studio are heavier, and, of course, more steady and convenient for use. It is of the utmost importance that the camera should remain perfectly and absolutely still during the exposure of the plate, the slightest vibration invariably destroying the picture; hence the selection of a strong and rigid stand is imperative. Unfortunately, a passion for lightness and portability has led the makers of photographic apparatus to construct stands of so slight a kind that they vibrate easily in a strong wind, or upon the slightest touch; and it therefore becomes the operator to select such a one as will resist these influences, even at the expense of a little extra weight and loss of portability. The camera should always be secured to the stand by means of a screw, as well to prevent accidents by falling as to check any vibration. The next piece of apparatus requisite is a holder or vice, to support the glass plate in process of cleaning. In the ordinary form, this consists of two slips of wood, having a groove or rabbet upon their upper edges of sufficient depth to allow of the insertion of the glass. Through these slips are inserted two rods of brass or wood, which serve to keep them parallel to each other. In the centre, between these rods, is inserted a screw, by means of which the plate is secured in the rabbets during the process of cleaning. For the purpose of cleaning the glasses, which, as we have before remarked, is a matter of the utmost importance, a supply of cotton-wool and several cloths and leathers will be required. These must all be cleansed before use, by washing them in a cold solution of common washing soda, and afterwards in several changes of cold water, soap and grease being most carefully avoided. The cloths and washed leathers should be most carefully kept, in a box free from dust, and, above all, from grease, and they should not be used until after the hands have been well cleaned and dried. A broad brush of camel's hair should be provided, for the purpose of removing any particles of dust which may adhere to the glass immediately before it is coated with collodion. This brush must be as carefully cleaned and kept as the leather and cloths. After cleaning the plate, it should be placed in a properly made box, with grooves for holding the glass in position, the cleaned sides all being placed in one direction.

For the sensitising of the plate, a glass or porcelain trough will be required, of a size proportionate to that of the plates to be employed. Upon the whole, glass vessels are to be preferred for this purpose, in consequence of their superior cleanliness in use, as well as from the fact of their transparency allowing of frequent examinations of the solution which they contain, in order that it may be kept perfectly clean and free from floating particles of dust or collodion, which would adhere to the sensitive surface, and cause spots in the finished picture. When a glass bath is used, a wooden casing will be supplied with it, with a loosely-fitting cover, which should always be kept over it when not in use. The form of bath most frequently employed is shown in section in Fig. 2. In this bath must be a dipper for the purpose of raising and lowering the plate during the sensitising process. The dipper simply consists of a slip of glass of sufficient length to reach from the bottom of the bath to about an inch above the top, in order to afford a good handle by which the plate may be easily manipulated. Upon this slip is cemented a second at a slight distance from the bottom, as shown in Fig. 3, which forms a ledge upon which the plate may rest. The cover of the bath should be so high as to allow of the bath being covered while the dipper remains upright. A properly-made bottle for holding the collodion should also be provided. The best form with which we are acquainted is that in which the stopper is enclosed in an outer cap of glass, accurately ground to fit the outside of the neck of the bottle, so as to prevent any escape of the collodion solvents by evaporation. This is important, as if evaporation is allowed to go on, the collodion will speedily become so thick as to run unequally over the plate, and cause stains and cloudy markings. Several developing-glasses will also be necessary. These are simply small vessels resembling tumblers, but having a lip on one side to facilitate pouring. For the fixing of the image we should advise the use of a dipping-bath, similar to the one already described for the sensitising process; as if the fixing solution be merely poured over the plate it is apt to act unequally, as well as to render the hands so impure as to cause stains in subsequent operations

Some operators recommend the use of a plate-holder during the development, but we are inclined to advise the careful handling of the plate by means of the fingers alone. A spirit-lamp is always a useful accessory in the laboratory, and will be found exceedingly useful in drying and varnishing the finished pictures. This will complete the list of apparatus absolutely necessary for producing a negative, and we may now proceed to describe the chemicals required, and method of using them.

Having provided himself with the apparatus that has already been fully described, the operator may now proceed to mix the requisite chemicals. In this matter the greatest care must be taken, as to the quantity, cleanliness, and purity of the weights and measures used and of the chemicals themselves. No guessing at the quantities can be permitted, as in some cases a few grains more or less will involve the certainty of failure. The operator should therefore provide himself with a pair of scales with glass pans, and weights from 5 to 500 grains. These, of course, can only be used for solids, and, consequently, several graduated measures of glass, varying from 1 to 10 ounces in capacity, should also be provided. After every operation, all measures, as well as the scale-pans, should be thoroughly cleansed, in order that no trace of the chemicals employed may be carried into solutions in which they are not required. Everything being thus in order, the operator may proceed to the mixing of the solutions.

The first thing requiring attention is the collodion. We shall not here describe the manufacture of this important compound, inasmuch as it is not likely that the operator will manufacture it for himself: we will hereafter describe the method adopted, and give the requisite formula. The best course of proceeding will be that of purchasing, say, one pint of bromo-iodised collodion of a good maker, asking that the collodion and the iodising solution be in separate bottles, in which condition they will keep an indefinite time. In order that the collodion thus procured may be rendered fit for use, it will be necessary to mix the two solutions; the proportions vary with different kinds of collodion, but that mostly adopted is 1 part by measure of the iodiser to 3 of the plain collodion. The quantities will, however, be plainly stated upon the bottles, and they must be strictly observed. Supposing, however, that the proportion of 1 to 3 is correct, proceed to iodise the collodion by pouring into a glass measure three ounces of the plain solution, measuring with the utmost accuracy. This, should then be poured into the collodion bottle before described. Now measure one ounce of the iodising solution in like manner, and having added it to the collodion, replace the stoppers, and shake the mixture for two or three minutes. After resting a few hours it will be ready for use; but it is better to allow an interval of twelve hours to elapse before applying it to the plate, in order that it may become thoroughly settled.

The next operation will be the preparation of the nitrate of silver bath used for sensitising the plates. In this matter, as in the last, great care is required as to cleanliness and purity of materials and measures, as the slightest impurity will inevitably produce failure and disaster. Carefully wipe the scale-pans before weighing out the nitrate of silver; and wash the measures in clean water, adding a final rinse of that which has been distilled. We should advise the operator to mix a good quantity of solution at once, as small mixings are always wasteful. Take of pure re-crystallised nitrate of silver (the ordinary common nitrate of silver will be of no use in this part of the process) 1,400 grains, which should be placed in a clean bottle, rinsed as the measures in distilled water, and add to this 20 ounces of distilled water; shake until the crystals are dissolved. To 20 ounces of distilled water, in a second bottle or measure, add 4 grains of iodide of potassium, and when dissolved mix the two solutions. A light cloudy precipitate will be formed of iodide of silver, which will speedily be re-dissolved upon the agitation of the whole. The solution should now be carefully filtered through two or three thicknesses of pure filtering paper, when it will be ready for use. Note that all solutions of silver must be made in distilled water, in order to prevent the precipitation of chlorides or carbonates, by means of the salts usually in solution in ordinary river or spring water. Also, that all filter papers, and those which have been used for absorbing waste silver solution, should be carefully preserved, in order that the silver they contain may be recovered.

The solution proper for the purpose of developing an image upon bromo-iodide of silver is one of the protosulphate of iron, which must be prepared in the following manner:—Take of pure protosulphate of iron 100 grains, and dissolve it in 10 ounces of water; distilled is preferable, but not essential. The solution of the salt will be readily effected if the crystals be pulverised in a mortar. To this solution add half a fluid ounce of glacial acetic acid, and the same quantity of alcohol; the whole to be well shaken and filtered before use. In very hot weather, or where the subject to be photographed is very intensely lighted, the quantity of acetic acid may be double that given above. The reason for adding the acid is that the iron alone would act unequally without some restraining power which would moderate its action; but, of course, if too much be used, the reduction upon the plate will be feeble. The alcohol is simply to cause the solution to flow evenly over the whole surface of the plate: it has no chemical action whatever.

The re-developer, or intensifying solution, consists of pyrogallic acid, in the proportion of 2 grains to the ounce of water, to which is added 1 grain of citric acid, for the same reason as the acetic acid is used in the first developer. The solution above given is simply for the purpose of adding to the intensity of the image obtained by the use of the first developer. It does not of itself develop any traces of an image after the application of the iron solution to the plate, although, from the density which it imparts to details which have been previously weakly brought out by the first solution, it frequently appears to do so. For use with the pyrogallic acid solution, one should be made containing 10 grains of nitrate of silver to the ounce, for which distilled water must of course be used. It will be hardly necessary to filter either of the two last-named solutions if care be exercised in their preparation.

The fixing of the photographic image—which, as we have before explained, consists in dissolving out the unaltered iodide or bromide of silver—may be effected by means of a solution either of hyposulphite of soda or cyanide of potassium. If the first-named salt be used, a saturated solution may be made by placing a quantity of the salt in a jug or basin, and pouring upon it boiling water. It should then be well stirred, and when cold the solution poured off the crystals. The best method of using this will be to provide a bath similar in construction to that employed for the nitrate of silver, dipping the plate in the same manner. The greatest care is necessary in order to prevent any trace of this salt being brought into contact with any of the chemicals in use, which it would inevitably render useless. Cyanide of potassium, although very much quicker in its action, and much more cleanly in use, is at the same time so dangerous and deadly a poison that we hesitate to advise its employment. Should this be determined upon, however, the salt should be dissolved in the proportion of 10 grains to the ounce of water, and kept in a closely-stoppered bottle, most conspicuously labelled, in order to prevent accidents. In the case of either hyposulphite of soda or the cyanide of potassium, common water will answer every purpose, and filtering is unnecessary.

In all probability, the operator will purchase the varnish required for the finished negative ready prepared, but we append the method of making one which is cheap and effective, in case he should wish to make use of it. Procure of the oilman or varnish-maker some of the varnish known as "best white hard," and dilute it with twice its volume by measure of methylated spirits of wine. It should then be well shaken and filtered, when it will be ready for use.

This will complete the list of preparations necessary for the production of negative pictures. We should advise the operator to prepare all the solutions required, and to carefully label the bottles containing them, as well as to definitely arrange the places where each is to be kept, before attempting to make any experiments; and although this may seem a tiresome task, he will find the advantage of this course as soon as he begins actual work.

We must again take the opportunity, in bringing this paper to a close, to direct the attention of the operator to the necessity that exists for perfect cleanliness in all operations connected with this useful and most pleasing art if he would command success. Without scrupulous attention to this point, the efforts of even the most skilful manipulator would be in vain.

GREAT MANUFACTURES OF LITTLE THINGS.—III.

BUTTONS (*continued from Vol. II., p.* 391).

BY CHARLES HIBBS.

We have now to speak of that class of button which is indebted to the turning lathe for its form. The most beautiful of all the substances used for buttons of this character is undoubtedly the shell of the pearl oyster, commonly known as mother of pearl. Those orient drops which serve our beauties for adornment, and our poets for metaphor, to so large an extent, owe some part of their attractions, no doubt, to the romance which attends the manner of their introduction alike to the light of day and to the world of commerce. Snatched from the bosom of the deep by adventurous divers, who daily peril their lives in abstracting those shark-guarded treasures of the sea, the shells, on being brought up, are eagerly and keenly scanned for the coveted pearls, which occur very few and far between. But the shell itself, which is quite a secondary object of the diver's regard, is destined to serve a purpose, more homely perhaps, but to all intents and purposes more useful, than the treasure it so very rarely encloses. The unpretending little buttons which serve as fastenings to the fronts of our shirts, are made out of shells fished up from coasts widely separated from each other, and are of correspondingly differing qualities. The best are gathered from the seas around Macassar; those of the next quality come from Manilla; a third, of a still commoner kind, are found in the Persian Gulf and in the Red Sea; and a fourth, the poorest of all, are brought from islands in the Bay of Panama, called the Pearl Islands. There is another kind, of a black colour, brought from the Archipelago of the Pacific, certain portions of which, when the black surface is turned off, will yield white buttons of a quality not inferior to the best Macassar; and at one time this constituted the entire commercial value of the shell, the black portion being thrown aside as waste. But capricious Fashion, which in its way makes more revolutions than war, decreed that black pearl buttons, for coats and vests, should for a time become the rage, and straightway the heaps of refuse, which had in many cases been buried to get it out of the way, acquired considerable value. The substance had a clear title to public favour, being very beautiful; and a set of picked buttons, highly polished, would shine with as many tints as the chameleon in different lights. Black pearl buttons are still extensively used for ladies' mantles, etc., and, turned of very small size, for ornamenting the tops of boots.

The mode of their production is simple, but involves considerable skill of hand. The first workman is called the "piece maker," and his duty is to cut out the blanks from the shells. A short tube of steel, the diameter of the button, with one end cut round its edge into a saw, is fixed in a common foot-lathe. He holds the shell firmly against this cutting tool while it is revolving at speed, and with some moderate pressure exerted, it cuts pretty rapidly through. Of course the largest buttons are cut out of the middle and thickest parts of the shell; the thin sides being available for the smaller sizes. The best workman is he who can cut up the shells to the best advantage. These blanks, or "pieces," have then to be "bottomed," which means taking off the rugged outside of the shell—that on which the waves have been beating—by means of the turning tool or the file. This will generally be the under side of the button, and, if turned, it is of a convex shape. The workman has a "chuck" of box-wood in his lathe, slit down with a saw to half its length, with a screw-clamp upon it to tighten it up. On the end or face, he has turned a little recess, corresponding to the size of the button, and when he has prized open the slit with a sort of jemmy, and inserted his pearl blank in this recess, it is held quite tightly enough for his purpose. The turning tool is a triangular chisel of steel, pointed at the end. The pearl shell being very hard, this chisel requires to be frequently sharpened, but when in good order it takes off the superfluous material, in the shape of fine dust, very quickly. The bottoming is done mostly by boys, and is good training for the more skilled operation of turning proper, which consists in putting the face or pattern on the button. The inventive genius of the pearl button-maker is concentrated on the very limited superficies contained in one side of a button. It has no other field for its exercise. The number and variety of shapes which he has succeeded in producing would seem impossible to a stranger. By the skilful guidance of the cutting tool, now applying the point, and now the sharp edges of the sides, the turner speedily hollows out the button into a graceful cup, undulates its surface into hills and valleys, or forms rim and centre into bold plateaux, relieved by deep recesses. There is room for some exercise of the artistic faculty in devising even the shape of a pearl button, the skill being shown in bringing out the colour of the shell by light and shade. The pattern-books of some makers will show common and vulgar, while those of others will be chaste and pleasing. The remaining processes are done by women. They consist of "hubbing," drilling, and polishing; the first named being the grinding out of certain little nicks or hollows which are supposed to give ornament. All these are performed in the lathe.

Pearl buttons for outer garments are now largely superseded by those called vegetable ivory, which have a no less curious parentage. They are made from an odd kind of nut, called the Corozo nut, which grows in clusters upon a species of palm-tree in Central and South America. In size and general appearance it is not unlike the potato, and a casual passer-by, on seeing a wagon-load of them shot down at the door of a button-maker, would think he was laying in a stock of that useful vegetable for winter. It is seldom solid throughout, being mostly decayed in the middle, and is something harder than wood, but not quite so hard as ivory. When sawn through, a good nut is a beautiful milky white, very clear and transparent, but exposure to the atmosphere soon destroys the delicate purity of its complexion. It will, however, readily take any tint in the dyer's vat, and this facility, which enables it to be made of a colour to suit the garment, is, combined with its neat and chaste appearance, the secret of its great favour with the public. This very beautiful and manageable substance has been known in the button trade only about fifteen years; some few ornamental articles, such as beads, etc., having been occasionally formed of it before that time. Ever on the look-out for novelty, the button-makers seized upon it eagerly, and at present the consumption of nuts by them in Birmingham alone is certainly not less than twenty tons per week. The material seems eminently adapted for many other small articles than buttons, and if the supply can be relied upon, there can be no doubt that other spheres of usefulness will speedily be found for it.

The first thing done is to strip the nut of its outer husk, which, being thin and hard, easily breaks and shells off, raising clouds of dirty brown dust. It is done by young urchins who are known as "nut-crackers," and who form perhaps the lowest class of labourers to be found in the trade. Mr. J. P. Turner, of Birmingham, says, "Every little rascal who is too wild for steady work can be set to do this; and consequently they are the veriest little Arabs to be found in any branch of industry, their destructive propensities being happily utilised in the manner described." The nuts are then cut up into slices by a small circular saw, and afterwards converted into buttons by a very expeditious and summary process. A tool, somewhat similar to a centre-bit, is fixed in a lathe; its cutting edge has been indented to correspond exactly with the pattern of the button to be cut; the workman presses upon it the slice of vegetable ivory, and while it is cutting the face, brings up with a lever an opposite pulley containing the tool which cuts the back. Both sides of the button are thus turned at a stroke. The white feathery shavings fly in all directions, and the workmen engaged in this operation look as though feather-beds had been emptied over them.

Bone buttons are produced by methods sufficiently similar to the above to enable us to dispense with a detailed description, as are also box-wood buttons, which are made in large sizes, and dyed, for police and military overcoats, etc. Ebony, kingwood, and other expensive woods, are treated in a manner somewhat different. The buttons are turned and cut from a wooden bar. Say that the button is to be an inch in diameter. A length of a few inches has to be cut from the log of ebony, and squared on the saw-bench to one inch; the end is spigoted to drive into the headstock of the lathe; and then the turner, having roughly taken off the corners to save himself trouble, turns on the end of the bar the semblance of a button, and having got the face finished to his liking, nicks the bar behind it with a sharp pointed tool until it is cut through, and the button tumbles off

In this manner he cuts his way down to the lathe, when he turns out with his chisel the bit of wood wedged in.

We may now proceed to examine the methods of producing buttons made of plastic materials, which generally owe their form to pressure. The foremost place in this category must be given to the horn, or more properly speaking, the *hoof*, button, the material being the hoofs of cattle boiled down to a sort of thick pulp. This kind of button can boast of a venerable antiquity, and large quantities were made, and sold at a very low rate, at the beginning of the present century. Hutton, the quaint historian of Birmingham, speaks of "the cloaks of our grandmothers, ornamented with a horn button nearly the size of a crown piece, a watch, or a John-apple curiously wrought." These, no doubt, were clumsy productions compared with those of the present day, which are in many instances distinguished by taste and elegance. Some of the designs are of the most elaborate character, full of fine detail; the soft material taking the print of every delicate line in the die. Unfortunately, this sharp and clear impression soon begins to wear off, and after a time the horn button becomes as smooth as an old sixpence.

The dies in which they are moulded are of brass, highly polished. A number of presses are ranged round the shop, each containing the top and bottom dies, or matrices, of the button. The operator, commencing at one end, puts a small quantity of the warm and plastic material into the mould, brings down the top die upon it with considerable pressure, and leaves it there. He then goes on to the next, and so on to the end, by which time the first button is cooled sufficiently to be taken out. The edges have afterwards to be trimmed, and the buttons are completed. The shanks, if any, have been previously placed in the dies, and the material presses round and encloses them, so that the attachment is perfectly complete. If it is a large size button that is being made, each press encloses but a single one; but for smaller sizes, the die may have a row of holes, each exactly the counterpart of the other. It will be seen that the skill and ingenuity consist, not in the actual making of the buttons, but in the execution of the dies; and it will perhaps be proper to describe the manner in which any required numbers of them are obtained in exact duplicate, although the description properly refers to another trade, that of die-sinking.

In the first place, a die is sunk in steel in the ordinary manner. When it is hardened and polished, a piece of red-hot steel is driven into the impression by repeated blows of a stamp. If properly done, the precise print of the die can be obtained upon this "hub," as it is called. At this stage, an opportunity occurs to enrich the design by the short cut of practising on the hub. For instance, if it is intended that the button shall have incised marks or letters upon it, or if any part of the design is to be sunk in its surface, now is the time to insert those particulars. If they were actually cut in the matrix, each of the intended depressions being left standing in relief, it would necessitate endless labour; but they can be struck in the hub, by means of punches, with very little trouble. All that is wanted is to finish up the hub to be the exact counterpart of the features of the intended button in every particular. Then, when it is in its turn hardened and polished, it will strike any number of matrices, from which countless millions of buttons can be made, all microscopically alike.

Porcelain buttons, which are not now made in England at all, are also fashioned in moulds. Thirty years ago, the idea was first introduced by a Birmingham man, Mr. R. Prosser, and taken up by the celebrated Staffordshire potters, Messrs. Minton and Co. The French, for some reason or other, took warmly to the trade, and probably by the unscrupulous use of child labour, drove their formidable competitors out of the market, and now have it all to themselves. There is nothing remarkable about the buttons, except their cheapness. The present wholesale price is about 9½d. for a great gross, viz., 144 dozen, neatly sewn on good paper, and made to look spruce.

Some kinds of glass buttons are moulded, or pinched, by methods not differing sufficiently from those described to call for further description; but there are other ways of producing them, which may be interesting. One method is identical with that which is used for making glass beads—indeed, the buttons *are* beads, fitted with a shank. Coloured glass is drawn into rods of the required gauge, each rod having a hole down the centre like that in the stem of a tobacco pipe. The workman breaks off a piece of this rod, threads it on a wire, and sitting down before a lamp, directs a jet of flame on to the end of it with a blow-pipe, and melts a piece off. He twirls round the wire with his fingers, and the fused bit of glass assumes a globular form by the cohesion of its particles. The shanks are affixed in an ingenious way. A piece of fine wire is doubled up close, and on the double end is soldered a small round plate, or "collett," not much bigger than a good pin's head. The bight of the wire is then passed through the hole in the button, coming out a little way on the opposite side; the collett preventing it from slipping completely through, and forming an ornament for the top of the button. A second collett is passed over the projecting wire, and pushed up close to the under side of the button; and then the loop is opened out to form the shank. The method of making solid ball buttons of glass, with shanks attached, is no less ingenious. The shank is formed first, of bent wire as before, with a little length to spare in the two ends; these are then spread out a little in the shape of a V; the loop of the shank is fixed in the lathe, and while it is revolving, the workman melts off upon it, with a gas-jet and a blow-pipe, sufficient glass to make a button, from a thin rod which he holds in his hand. The glass wraps round the wire in a ropy form, just like so much melted sealing-wax, but a few turns under heat makes it fall, of its own accord, into a true spherical shape, perfectly smooth and seamless.

These last two varieties of button, though we have included them in our third class, as being made of plastic material, do not owe their form to pressure. We have now to speak of one, which, though pressed into shape, is not made of plastic material. This is the papier-maché button. It is principally used for children's boots and shoes, and is consequently made only in small sizes. The blanks are cut out of sheets of thick pasteboard in the ordinary manner with a press, the punch at the same time making a stab in the centre of the disc to receive the shank. The shanks are stuck in by children, and the soft button, which is no more than a bit of brown paper, being put under a heavy press, and subjected to a powerful squeeze, is compressed into shape, and becomes as hard and smooth as ivory.

Such are a few of the processes in vogue in this remarkable industry. We have only aimed at describing the leading features of those which appear to head the groups, their modifications being so numerous as to make it hopeless to try to bring any detailed account into reasonable compass. A mere list of the various kinds, patterns, and designs of the buttons now in the market would fill several numbers of this periodical. It is hoped that what has been written will enable the reader to comprehend sufficiently the main principles of button-making. A few words as to the position of the trade in this country may not be inappropriate in conclusion. It is far from being one of our monopolies, or even one of our specialities. Mr. J. P. Turner, the authority before quoted, puts down the number employed in all branches of the trade in Birmingham at about 6,000; a total which would not be materially swelled by including the whole kingdom. The French Official Catalogue of the Exhibition of 1867 stated that the number then employed in France was 22,000; and further, that the industry, comparatively insignificant thirty years before, had made extraordinary progress, and that France was then furnishing to the civilised world by far the greater part of the whole button manufacture. Mr. Turner, on the other hand, supposed that "the quantity exported from *Germany* to other countries must far exceed that from both England and France together." We are, therefore, completely distanced by two competitors. The causes of French supremacy are not far to seek. In an article susceptible of such infinite variety of design and ornamentation as a button, the high art education of the French, their natural aptitude, and long experience in the production of elegant trifles, find a most convenient opportunity for their exercise. The result is, that they have established a reputation for the artistic varieties with all the buyers of the world, and these, also attracted towards Paris as the Mecca of fashion, seek to complete their purchases without coming to England. The German buttons only excel ours in cheapness.

By way of contrast to the cheap porcelain buttons before mentioned, we may refer to the once fashionable steel buttons, cut with facets, which used to be made and sold by Matthew Boulton at 140 guineas the gross!

SOLDIERING.—I.

BY A STAFF OFFICER.

SYLLABUS.

MATTERS to be considered in the organisation of every army—

A. Preparation of individual soldier.
- I. How men are obtained for it.
- II. How they are equipped.
- III. How they are trained.

B. Building up an army out of the individuals which compose it.
- IV. Units of command.
- V. The higher organisation, from the first units into new commands.
- VI. Supplies, and means of obtaining them.

I. Means of obtaining men:—Voluntary enlistment; compulsory enlistment.

II. Equipment. Subdivided:—
- (*a*) The agents employed by men in actual fighting.
- (*b*) Clothing.
- (*c*) Immediate necessaries.

(*a*) The active agents in war—
- (1) Fire-arms, large and small.
- (2) Hand-to-hand weapons.
- (3) The horse.

How the progress of invention has affected the qualities which are of the greatest value in a soldier.

How the present condition of arms and the use of the horse cause the subdivision of armies into the three great branches or "arms" of the service—
- (A) Infantry.
- (B) Cavalry.
- (C) Artillery.

The division into the three arms must be taken into account in considering the conditions which fix the nature of the clothing and immediate necessaries of each arm—
- (1) What is essential for all arms.
- (2) What conditions must be attended to in the equipment of each arm.

III. Training:—
- (*a*) Discipline.
- (*b*) Drill.

IV. Units of each arm—
- *Infantry:* The battalion, space occupied, what fixes it.
- *Cavalry:* The squadron, space occupied, what fixes it.
- *Artillery:* The battery, its strength, how subdivided.

V. The higher organisation of an army, from the units into new formations. Proportion necessary to be observed between the arms. Organisation of—
- (*a*) Infantry.
- (*b*) Cavalry.
- (*c*) Admixture of artillery with these.
- (*d*) Completion of the whole into regiments, brigades, divisions, corps, by the addition of engineers, etc., and the action of a proper staff.
- (*e*) Organisation actually adopted by various nations during recent wars.

VI. Organisation of the non-combatants. Main points to be considered:—
- (*a*) Supplies for an army. What these include; conditions to be fulfilled. What experience has taught as to the best means of obtaining them.
- (*b*) Transport—railway, water transport, road work, wheel-carriages, pack-animals.
- (*c*) Care of sick and wounded. Principles to be attended to.
  - (1) Hospitals, their necessary subdivision of classes.
  - (2) Transport of sick and wounded, and of stores necessary for them, special care for the removal of sick and wounded from the field.
  - (3) Organisation of medical attendance.

INTRODUCTION—OBJECT OF THESE PAPERS.

WHAT AN ARMY IS—THE FIRST NECESSITY FOR EVERY ARMY IS ORGANISATION—WHAT WE MEAN BY "ORGANISATION."

The following papers are intended to fulfil, as to that business of "soldiering" which has of late years threatened to become so terribly important a one in Europe, the same purpose which the other papers of these volumes have accomplished for other businesses, arts, and trades. There have been already papers contained in THE TECHNICAL EDUCATOR which were chiefly interesting to those who wished to know something of the employments of soldiers—of the arms they use, and of the fortifications which they attack or defend; but the subjects to which a soldier's attention has now-a-days to be directed are so numerous that these, and not a few other matters, can only be considered as branches of the great business on which he is occupied.

In order to understand what a soldier is, and what he has to do, it is necessary to become acquainted with him as a member of the great body to which he belongs; and to know what is required of him, in order that he may do his duty in it. The connection of the different subjects which he has to study, and their bearing on his main business, will then become apparent.

All a soldier's work is either a small contribution on his part towards the common efficiency of the whole army, or a preparation for performing his part towards that end; and it is, therefore, as unsatisfactory to study his individual duties without examining the constitution and nature of the body to which he belongs, as to examine the work of a finger or a thumb without any study of the hand or the arm, of which it is a member. But if it is impossible to become acquainted with the real nature of a soldier's calling without thus getting to know something of the nature of an army, it is still more hopeless to study what is called the "Art of War" in its higher features—to attempt, that is, to comprehend why battles and campaigns are won and lost, without a thorough acquaintance with the manner in which armies are held together, and with the conditions of their effective action. For battles and campaigns are not fought with collections of men who start from their homes in the morning, engage in a struggle of physical strength in the afternoon, and return to their homes in the evening, but by bodies so organised and prepared for action that they live under conditions of existence altogether different from those of the individual men of which they are composed, and yet are entirely created by the aspect which the necessities and characteristics of the bodies and minds of men assume, when they are brought into the strange new organism which is created by the moulding into one homogeneous whole of their several individualities.

A variety of questions have sprung up in regard to the army of late years, which all who take an interest in the future of their country wish to be able to answer correctly. Hardly any of these are answered by attempting to give an account of the several parts of the studies on which a soldier is necessarily engaged. Almost all of them will be understood if the nature of an army is properly considered. Of these, some of the most important may be noticed, as they will make the object of our work much clearer. We will put them in the form in which we have heard them. "How can sensible men take any interest in what is at best only a dreary preparation for a duty which may never require to be undertaken?" "What can be the use of sending our volunteer battalions down to a review where they do nothing but march, and never fire a shot? Who is to blame that this is all that they learn?" "Can our army march? and is it a proof than an army can march because our regiments, batteries, and squadrons are as well up to their work as any in Europe, or is something else required to enable an army to march, which has nothing to do with the power of the men to walk long distances, endure fatigue, and know their drills well?" "What are the advantages and disadvantages of compulsory service? Is it economical?"

An army is the instrument by which the rulers of a nation endeavour to give force to their views and wishes in dealing with other nations. In considering, as we are for the moment doing, the object with which those who create the army will set to work, it is irrelevant whether the rulers of the nation are, as is the case with a free people, simply the representatives of the nation itself, or whether a despot handles the resources of the country for his own purposes. In either case the object will be to develop the force in such a manner that it shall act only under the impulse which is imparted to it by the will of the ruler, and yet shall be as powerful an instrument as possible in the hands of him who wields it. This result has, in fact, to be obtained by utilising the services of an immense body of men, each of whom has as strong an inclination as men in general have to carry out his own wishes, and no one else's. Moreover, without any very special preliminary test as to courage, we

intend to exact from these men an indifference as entire as we can possibly obtain to another question, on which most men are a good deal interested—their lives.

Again, as in order to obtain the object for which the army is to exist, the prime duty of these men will be to fight, they will not be able when actually on a campaign to perform effectively for themselves any one of those duties which men usually undertake in ordinary life; they cannot see that proper supplies of food and stores of all kinds are present at the spot where they need them, and some means must be taken to secure their constantly having them at hand when they need them, otherwise they will not be able to fight at all. All these and many more matters have to be well considered, and in the result an army has to be rendered at once as self-dependent as it can possibly be; as able to act as a single unity, and yet the fully-developed force of every individual must be put forth to the utmost possible extent, in order that the common force may be the greatest possible. The means by which these results are brought about is what we call the *organisation* of an army. I am anxious for a moment to insist upon the word, because an army is often likened to a machine, and I have myself spoken of it above as an instrument. An army may so far be an instrument that it is used for a specific purpose, but in so far as its interior economy and working is concerned, it is marvellously unlike a machine, and marvellously like a vast living body, instinct with a most definite life of its own, in which the duties of the several *organs* are as distinct as they can possibly be, and yet in which no small part of the duty of each is to co-operate with every other for the common end of the efficiency of the whole body, and in which the object of him who would develop its force is to bring out the full effectiveness of every organ in the highest possible degree.

SANITARY ENGINEERING.—XIV.

THE VENTILATION OF HOSPITALS.

In our previous papers on this subject, we have treated the ventilation of private houses and public buildings, and we now devote a paper to this special heading as one of unusually general interest at the moment, giving some practical examples of the different systems adopted. The first instance we select is that of the New Infirmary, as it is called, erected for the Wandsworth and Clapham Union about four or five years ago. Natural ventilation only is employed; there are neither special furnaces, steam-power, nor other mechanical aids; and we take as an example a single ward 123 feet long, 24 feet 6 inches wide, and 12 feet high.

Standing out clear in the centre of the room, and about equidistant from each end, are two upright chimney breasts, each with two open fireplaces, one on each side, facing the long way of the ward; these have a flue unconnected with the smoke-flue, running along and under the floor, and communicating with the external air entering at the back of the stove into a chamber constructed for the purpose; and the fresh air, thus warmed, passes out into the ward by openings in the front of the upper part of the stove. Immediately above these gratings, which are made of terra cotta, there are others exactly similar, also communicating with the air outside, but from a totally different direction. The smoke-flues are constructed on the principle illustrated in our last paper—*i.e.*, at each angle of the circular flue there is a small air-flue, which in this case runs up to the roof, where there is a chamber specially built, and open on all four sides to the external air, enclosed, however, by gratings of open terra cotta, and from this a constant down-draught of fresh air is maintained into the ward. Again, in each pier between the windows on both sides of the wards are Sheringham's ventilators (as described in Vol. III., page 22), regulated by lines under the control of the nurses, and opening through the wall directly into the external air.

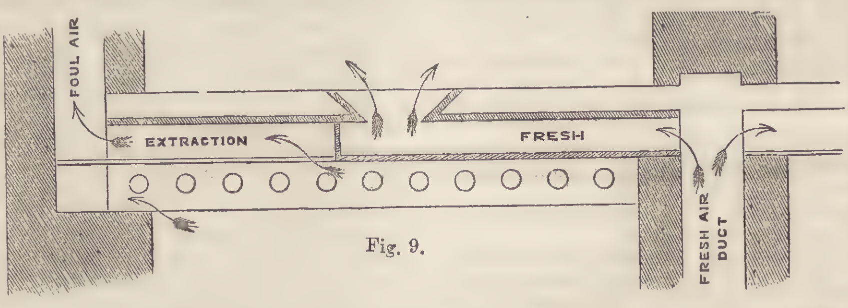


Fig. 9.

It is, however, a well-known fact in hospital experience, that certain classes of gases generated in disease are heavier than the ordinary atmosphere, and fall to the ground; these, if undisturbed, accumulate under the clothes below the bed as under a bell-receiver, and as in the ordinary course of traffic nurses pass by the bed, are occasionally disturbed and set moving about the room. In this case under the head of each bed there is fixed an ordinary "hit or miss" ventilator of metal, opening direct through the wall into the air; by opening this a few minutes at any time the gases are freely dispersed and removed by the ordinary exits of foul air. Lastly, as a sort of perpetual safety-valve, there are flues in the external walls running up to the roof, opening into the ward by self-acting valves, somewhat similar in construction to those described as Dr. Arnott's (Vol. III., page 22). These flues are calculated at one inch of area for every fifty cubic feet of air contained in the ward, and lead into the open space contained within the roof, which acts as a hot-air chamber, and has louvres at the ridge by which the foul air finally escapes. We may mention here that, as an additional precaution, the drains are ventilated by separate flues that run up in towers to a height considerably above the general roof level, and that a receptacle for charcoal is provided at the top of each flue as a disinfectant.

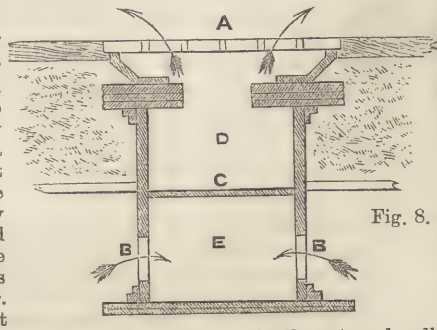


Fig. 8.

Having described one of the most perfect of modern systems for what we call natural ventilation, we now proceed to give the detail of one or two others where artificial aid is employed, and we next take up the new buildings at Guy's Hospital, of which the first portion with the central tower was erected about twenty years ago, and the other wing only within the last few years. In this case there are three lofty shafts, two for the admission of fresh air, one on either side of the principal entrance, and the third towards the centre of the building for the extraction of the foul air and the exit of the smoke at a level very much above the height of the other towers, from which it is situated at some considerable distance. From the top of the admission shafts the fresh air is carried down to a chamber in the basement, where it is heated by passing over a series of hot-water pipes, and then ascends by numerous flues contained in the brick piers in the centre of the wards. The wrought-iron box girders that carry the various floors are here brought into play, and contain both the admission and extraction flues (Fig. 8). There are twenty-two of these girders in each ward, and the longitudinal section (Fig. 9) shows the course of the air.

The upper flue, embedded in the concrete of the floor, admits the fresh or warm air as required by gratings in the floor; and the lower flue, which is immediately below the ceiling of the wards, receives through a number of circular apertures the vitiated air from the ward below, which is then carried by a series of independent flues to the vitiated air-chamber in the attic storey, and thence to the great shaft in the centre of the building.

In the portion of the building erected some time ago a system

almost directly the reverse of this is in operation as regards the admission and extraction of the air, though the general arrangement of the flues as far as the building construction is concerned is very similar. The fresh air is introduced by gratings in the walls close to the ceilings, and extracted afterwards through gratings in the walls near the floors and immediately under the heads of the beds. There is something to be said in favour of the latter system; but so long as there is a thorough change of atmosphere, and the temperature is pleasant without draught, it does not materially matter how the change is accomplished. The experience of a year or two will doubtless prove beyond a doubt which of these two diametrically opposite systems of air currents is to be preferred. The heating apparatus in the basement is only supplementary to the open fireplaces, of which there are four in each ward, as well as another in the ward kitchen, the ground floor having open fireplaces only, and the upper floor or dormitory hot-water pipes circulating through its entire extent. There are varying modifications of this system of warming adapted to the museum, the grand staircase, and other portions of the building, into the detail of which we need not here enter, as the general principle upon which they have been carried out is already sufficiently explained in our previous paper on warming by warm water.

A general description of the arrangements would be foreign to our present purpose, which includes only an explanation of the general principles adopted in the arrangement of the ventilation.

We conclude our short series upon this subject by an account of the system adopted at the last erected and largest of the London hospitals—viz., St. Thomas's, adjoining Westminster Bridge, which we may say combines the advantages of the natural and distributed system, with the introduction of artificial aids to ventilation in detail.

Taking a single ward as a sample of the whole, the arrangements are as under:—There are three fireplaces in the centre, facing endways of the ward, and the heat of the fire is made available for the up-draught of an extraction-flue which surrounds the smoke-flue of each particular chimney with an iron casing, and removes the foul air through a grating at the ceiling level; fresh air is supplied to the fire and the ward by a flue running within the levels of the floor, and communicating directly with the external air, which is warmed by its entry into a hot-air chamber behind the fire before it is admitted into the room. The pavilions of the hospital are large blocks of building, of which each floor forms a ward with its necessary adjuncts, lavatories, etc., nurses' rooms, and kitchens, and to each pavilion is provided a separate and complete set of hot-water apparatus, having its boiler and furnace in the basement storey; the flue from this is carried up to the turret level in an iron tube which forms the centre of an air-shaft or extraction-flue for the block to which it belongs; and on each floor are two large coils of hot-water pipe in addition to the open fires, each coil supplied with fresh air by a separate air-duct contained within the level of the floor, and drawing its supply from a grating in the external wall. From the ceiling and floor level there are also separate gratings communicating with specially constructed flues, all of which lead into the one central extraction shaft annexed to the smoke-flue of the hot-water apparatus in the basement of each pavilion.

The sources of supply of fresh air, or the fresh air-ducts, are therefore two in number:—

1. The flue from the external air communicating with the back of the stoves, three in number in each ward.

2. The flues that communicate in the same way with the hot-water coil, two in number in each ward.

The extraction ducts are of two descriptions:—(1) Those surrounding the flue of the open fireplaces, three in number, running up to a chamber in the roof, and communicating with the main extraction shaft from top and bottom of ward. (2) Those connected by flues with the same extraction shaft containing the smoke-flue of the hot-water apparatus, of which there is one provided to each pavilion in the area of staircase adjoining the shaft of the lift from top to bottom.

The three examples quoted illustrate different methods of ventilation: the first, the Wandsworth Infirmary, showing what may be called the natural system, in which the common open fire is the only assistance to the ordinary admission of external air.

The second, Guy's Hospital, exemplifying the introduction of what we may call a complete system of artificial ventilation throughout the various floors of an extensive building arranged and constructed so as to be under entire control.

The third, St. Thomas's, while availing itself of the powers conferred by either system, preserves the control in detail, which must sometimes be desirable in individual wards. All these various combinations work satisfactorily, and no doubt, if it were desirable, we could furnish many other examples of varied methods for the introduction of fresh air and the removal of foul; but if this paper is read in connection with our two previous papers on ventilation, and also with that on heating by hot water, any details necessarily omitted for want of room may be easily supplied, and we here complete our series of articles on this subject to proceed to the equally important sanitary topic—viz., drainage.

SILK CULTURE.—II.

By Alexander Wallace, M.D.

TIME FOR HATCHING — MANIPULATION FOR HATCHING — FEEDING WORMS IN EARLY STAGES—PAPIER FILETS AND NETS—SUCCESSIVE MOULTS OF WORMS.

Early in the spring, on a warm sunny day, it is usual to wash the eggs with water at a temperature of 65° to 70° Fahr. Red wine is sometimes used for this purpose. The eggs are then dried in a warm room, but without a draught. Early in April, in Italy, the eggs hatch out; in France, early in May; and in England, the first week in June. If the eggs are kept in a cool, airy, dry cellar at a temperature of 50° to 55°, there is no fear of their hatching out prematurely; but at a higher temperature they will very probably do so. Towards the end of May, when the weather is warm, bring them out into the *magnanerie*, gradually raising the temperature 5° daily, till 70° or 75° is reached, at which temperature the eggs will hatch. A higher temperature is recommended by some, but I have found my eggs hatch out remarkably well at 60° to 65°.

The manipulation necessary for hatching out is as follows:—Light a fire in the stove of the *magnanerie;* in the evening place the cloth or card on which the eggs are laid; or if loose, place the eggs in a thin layer on linen, on a table near the fire, and cover them with muslin net. Ordinary cap net is admirably adapted for this purpose, of a size sufficiently small to permit the worms to creep through easily. Early in the morning the worms hatch out, at first one or two only as forerunners; then, perhaps, the next morning fifty or sixty worms, and then they hatch out in bulk. In three or four days, or at most a week, the worms ought all to have hatched out. It is a matter of great importance to keep each day's hatch separate, as, theoretically speaking, those born on the same day ought to pass through all their changes together, and spin their cocoons on the same day; but this is rarely seen in practice, though it is possible for the bulk to pass their changes at the same time; a card, therefore, is placed with each day's hatch and the date written thereon, and each moult is noted on this card, which gives, so to speak, the life-history of that tray. The worms having hatched out, crawl speedily through to the upper surface of the net, and may then have some finely-cut leaf scattered over them thinly; and as some worms hatch out during the morning, I do not remove the muslin net till midday, when it is placed with the worms thereon, on a newspaper, in the position it is to occupy as No. 1 tray, during the life of the worms; a fresh piece of net is then placed over the eggs. Should any more worms hatch out, pieces of cut leaf, of a little larger size, are placed near them; on these they crawl, and are then easily removed by a pair of forceps to their companions. This process is repeated day after day till all the eggs are hatched out, or nearly so, and each day's hatch numbered consecutively. It is not worth while to keep the few early or late worms, the care and trouble expended on a tray containing few being greater than that expended on a large number. It is desirable, therefore, to have trays which are well filled with worms. It is well also to be provided with double the weight of eggs intended to be raised—viz., to have 20 oz., where it is intended only to rear 10 oz.; for unforeseen losses may occur, or some worms may be lost through disease, which, if there are no spare eggs, cannot be replaced; therefore, as eggs cost much less than worms at any age, and as the care and trouble of feeding small worms, as well as the expense of leaf, is at its minimum, it is real economy to provide a double

portion of eggs. The fresh young shoot of the mulberry may be gathered and given to the young worms, cut fine with a knife or scissors, or by means of the mulberry-cutter, a machine made like a chaff-cutter, which greatly economises the labour of preparing the leaf. It is, however, scarcely worth while to use this machine for the first age, except where very many worms are kept, as enough food can then easily be prepared by means of scissors or knife and a chopping-block; the leaf should be cut up in pieces not larger than the size of a pea or bean, and may be given four times daily—at six a.m., at ten a.m., at two p.m., and at six p.m. There is a great art in distributing the cut leaf to the worms; the object being to give them just as much as they will eat, and no more; too much leaf will be wasted, the worms crawl on to it and soil it; and if this accumulates in a moist state, it is apt to decompose and emit a noxious vapour very deleterious to the worms. The bed on which the worms rest, consisting of their excrement and of the unconsumed food, especially the stalks and ribs of the leaf, should be so crisp and dry that no effluvium can arise, and no gases be generated. When the bed reaches to the thickness of a quarter of an inch, it is time to give the worm a clean bed. This is accomplished by spreading over the worms, early in the morning, a net having meshes just wide enough to allow the worms to pass through easily; on this new bed fresh food is lightly sprinkled, and the worms crawl through or "rise to their food" with great zest. At noon the net may be lifted off, with the worms and their fresh food. Should any worms remain behind (*retardaires*), they are weakly ones, and may, if the stock be abundant, be thrown away, as not worth further trouble, or if required, a spray of mulberry may be placed over them; on this they crawl, and may then be removed, but not to their former companions; they must be put back a stage to the next tray. It is not desirable ever to touch the worms with the finger or thumb, except, perhaps, at spinning time, but even this should be avoided as much as possible. On the Continent, papier filets, or perforated paper, are used instead of nets, in four sizes, having different sized holes for the worms to creep through according to their ages. These are very cheap, being stamped by machinery, but they do not last for more than two seasons, absorbing moisture and becoming soiled. Nets, therefore, which can be washed every season are preferable, though more expensive at the outset. When there are two or more attendants, it will be well for one to go round early in the morning, and mark the trays which require changing (*i.e.*, fresh beds), with some sign agreed upon, such as a piece of paper, or card, or pill-box, on the tray; the feeder following with the fresh food, passes over that tray, till the clean net is put over the worms. In feeding, it is well to sprinkle the cut leaf at first all round the edges of the tray. Worms always follow the leaf, and as they grow larger, require more room; by feeding round the edges at first, the area for the worms is gradually and slowly increased, and more space is given. When the worms get too thick on a tray, they must be divided into two lots; to effect this, a net is spread over half the tray, and fed over. When the worms have risen, the net may be removed to a contiguous tray; but it is desirable to keep the worms of the same age near together, for reasons presently to be mentioned, the elder ones at one end of the room, the youngest at the other end, always to begin with the elder ones, and so go through to the youngest. Therefore, supposing there are six tiers or trays on each upright stand, it will be well at first to occupy two only of these with worms in their first age; those two, however, will in time occupy the whole of the six trays. If, however, these other four trays were occupied from the first with other worms, a great deal of shifting must from time to time arise of the whole of the brood, causing extra trouble to the attendant, and disturbance to the worms. Again, it is an advantage to keep them in regular order, the eldest first, and so on, always inspecting the elder worms first; for the simple reason that as each batch is a day older than the next, so in their successive changes the second batch will be, on any given day, exactly in the same condition in which the first batch was the day before. This simple rule enables the attendant to foresee regularly the coming changes, and to provide accordingly clean beds, more or less food, etc. etc., according to requirement, as he has to do one day exactly the same as he did the

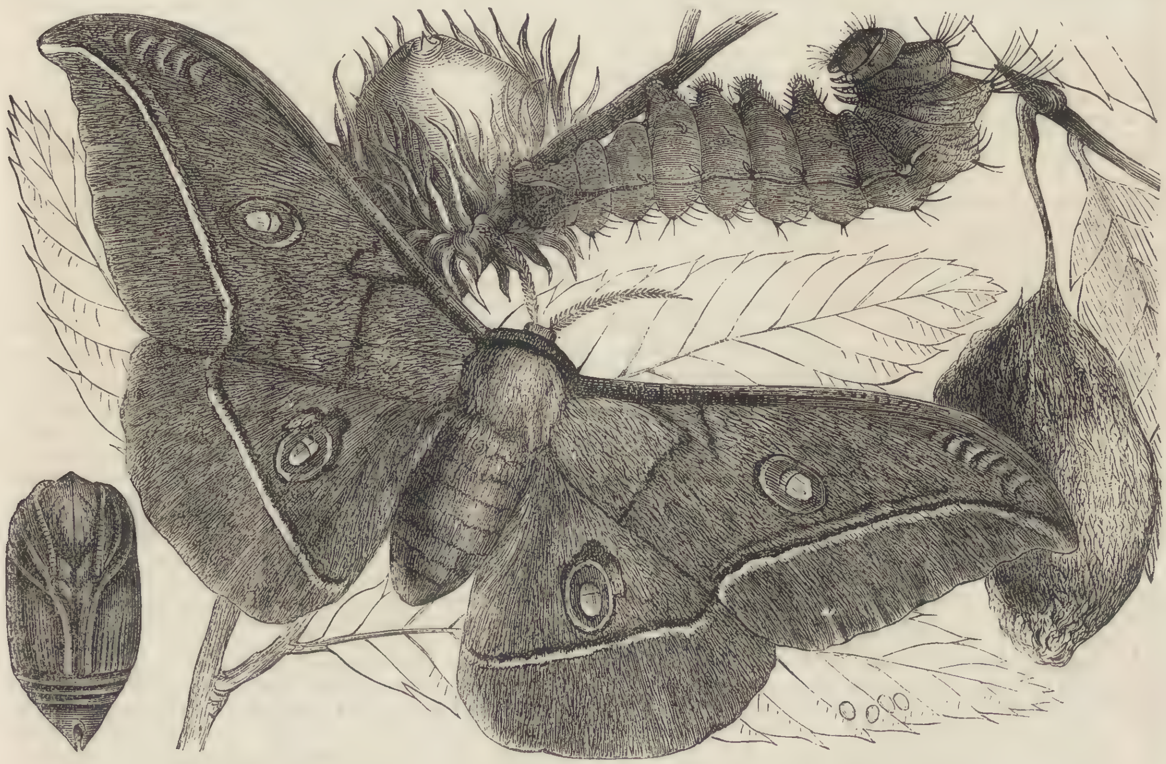
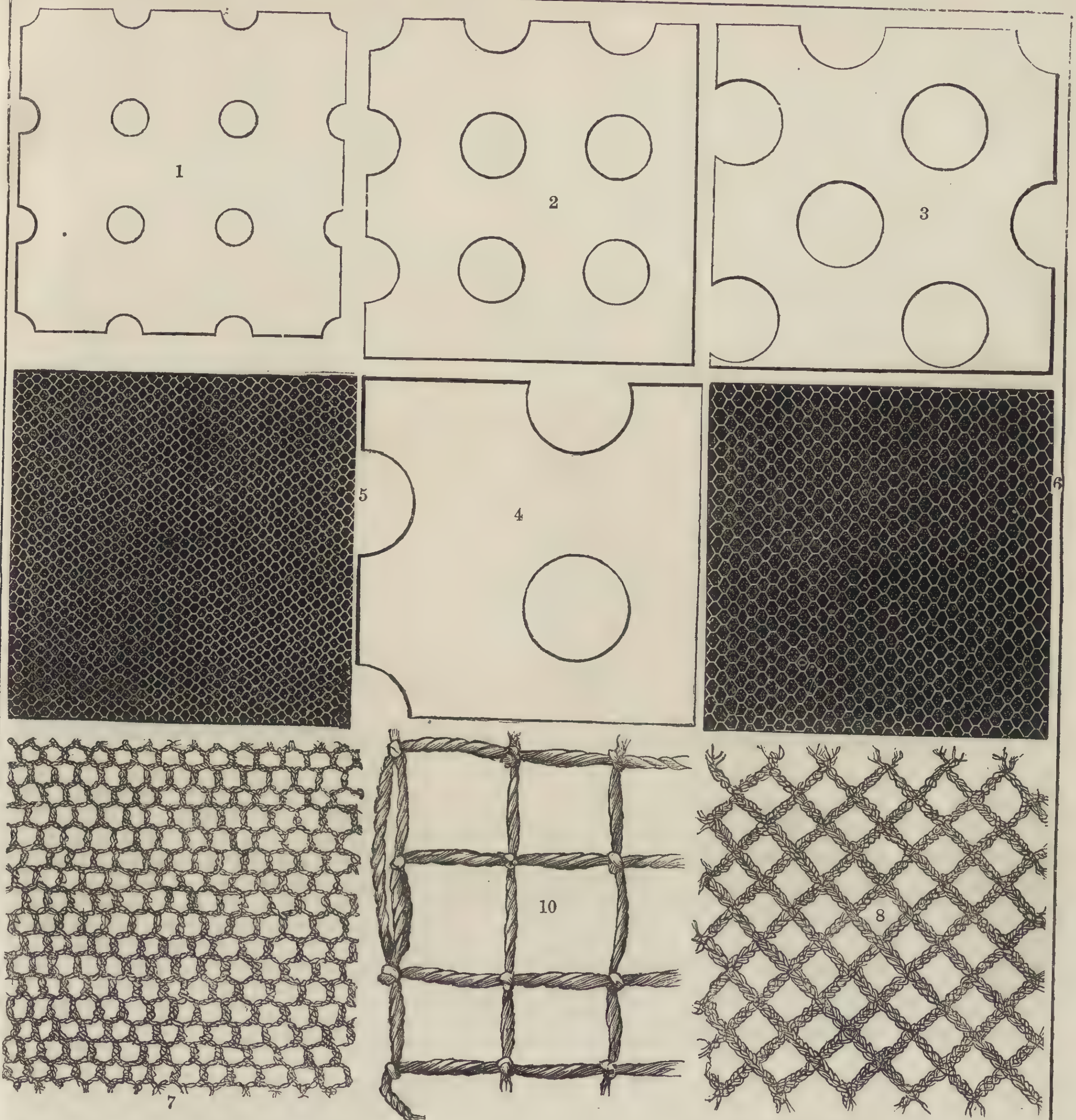
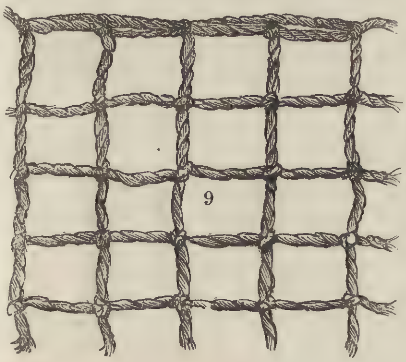


Fig. 3.—THE CATERPILLAR, COCOON, CHRYSALIS, AND MOTH OF THE BOMBYX PERNYII.





REFS. TO NUMBERS OF FIGURES.

PAPIER FILETS,

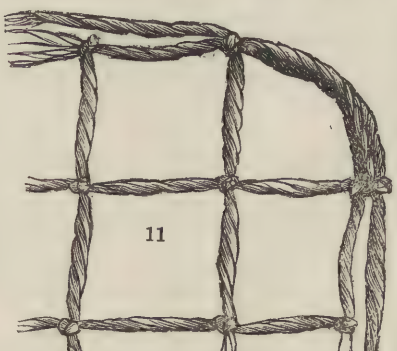
Machine made in four sizes.

1. For young worms.
2. For second and third ages.
3. For third and fourth ages.
4. For last age.

NETS.

5. Fine cap net to spread over the eggs, and for the first change of bed.
6. Larger meshed cap net for worms after first moult.
7. Machine-made nets for worms after second moult.
8. Ditto for worms after third moult.

9, 10, 11. Three different-sized mesh-nets, hand made, for worms in fourth and last stages.



day before to an older lot. In feeding, it will be found much easier to distribute the food evenly and sparingly when the hand is full of food than when only a small portion is taken up. It may be scattered in two ways, the palm being uppermost and the fingers rigid, more or less open, or manipulated by the fingers and thumb, the palm being undermost: I prefer myself the first mode. Attention must also be given to the age of the worms. After a moult the first feed should be spare, and it is also desirable to change their bed as soon as possible. After that they become very ravenous and consume a great deal of food. Again, as they approach a moult they eat less and require a light feeding, certain changes then ensue, their bodies become light coloured and somewhat transparent. They spin a secure foothold, to which they attach the hind-feet, and this done, they elevate the fore part of their bodies, their head standing up sometimes like that of a snake. In moulting, as is the case of lobsters, the skin of the head, face, legs, and body comes away, as also the lining membrane of the spiracles, or breathing apparatus, and of the intestinal canal. The creature emerges with a loose, wrinkled skin and a larger head, and seems a much bigger caterpillar than he was before. Now the result of the new face growing steadily behind the old one is to push off the latter, which, being smaller, leaves the upper portion of the new face visible. Hence, at the junction of the face with the collar or neck there is visible a greyish-looking triangular patch—in fact, the upper portion of the new face, and this, when observed, is the most certain and characteristic sign that a moult is in progress. Moulting generally occupies about forty-eight hours, but may be retarded by a cool temperature. Worms that have moulted can always be distinguished from those that have not yet done so, by the greater size of their heads. There are four moults in the worm's life; after each it greatly increases in size. There is also the emergence from the eggs, the change from the caterpillar into the chrysalis, and again the change into the moth—in all seven stages or ages, and the entrance into each new age is marked by the putting off the skin or exuvium peculiar to the former age. It is a wonderful reflection, yet true, that the tiny newly-born worm should possess the germs of six exuvia, each of them larger than the external ones, the innermost skin being the largest of all; yet so it is. It is important to recognise the impending moults which occur at regular intervals, for then the worms do not feed, and not only would food be wasted upon them, but it would inflict a positive injury; for if scattered over them at that critical period, they would be unable to rise above it, having attached their hind-feet firmly to the silken threads spun for that purpose, from which, if they are by accident released, death is the inevitable result. Moreover, their spiracles, or breathing apparatus, thirty-two in number, situated a pair on each segment just above their legs, would be unable to perform their functions (were the worms smothered by fresh food when unable to rise), respiration would be feebly performed, and disease or death ensue. It is more important to supply silkworms with an abundant supply of fresh pure air of regular temperature, avoiding draught, than with food; the latter they can go without for a period; but if deprived of the former they become unhealthy. I have often seen worms turn discoloured, and perish from being smothered while moulting, by a too liberal supply of food.

Moulting is performed as follows:—A series of contractions and extensions take place inside the old skin, by means of which the legs are withdrawn from their old envelopes, and the creature, so to speak, moves forward inside his own skin. This is evidenced on close observation, (1) by the hind-legs or claspers being observed in motion anteriorly to the old claspers; and (2) by the inner lining of the spiracle being drawn out to the extent of one-eighth of an inch in a worm moulting for the last time; these show as an interrupted white line running laterally with the spiracles. When this is observed, the active change has begun. Hitherto the worm has been motionless and passive, waiting till all was ready. Very soon, owing to pressure from behind, the animal, as it were, walking forwards within the old skin, rupture of this old skin takes place at the collar; the neck is then pushed forward, the old face still remaining on: first one pair of fore-legs and then another is protruded. The hind-legs of the old skin all the time remain firmly attached to the silken cords; but should this attachment unfortunately give way, the creature seems unable to extricate the hinder portion of its body, and the old skin turning brown, remains as a ligature preventing defæcation and respiration, and causing slow death. The worm having freed its legs, pair after pair, crawls forth, a new creature, drops its old face, and, erect on its hind-legs and claspers, waits till the new integument of the mouth, head, and legs, etc., harden; after which it starts off in search of food. The old skin, with lining membrane of spiracle and intestinal canal, remains a thin brown mass, still attached to the bed. Each moult brings with it characteristic changes in appearance, so that the age of the worm is well known by the experienced feeder. When first hatched the worms are such tiny black or brown specks, that they are hardly visible to the naked eye when resting on the cut leaf. Their presence can, however, be easily discovered if the attendant breathe upon the food. This is distasteful to the worms, and they immediately move their heads and bodies from side to side. This is a useful method, when looking over the litter after the worms have been cleared, to ascertain if there are many *retardaires*. The following lines show the sizes of the worm—(*a*) when just hatched;

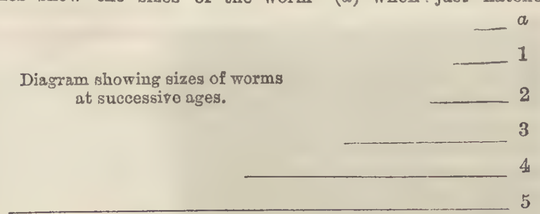


Diagram showing sizes of worms at successive ages.

1, 2, 3, 4, at the close of its different ages; 5 the length of a full-grown worm just before spinning.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

III.—INTERNATIONAL MUSEUMS.

Construction, Arrangement, etc.—At the International Exhibitions of 1851 and 1862, the exhibits of each country were arranged in separate "courts," the various objects being grouped in these under classes and sub-classes, according to a recognised scheme of classification. Though well adapted to meet the national pride of every country, and the natural feeling for pomp and display, such an arrangement proved eminently inconvenient to all earnest students who wished to compare the natural products or manufactured articles of one country with those of another—having to toil from one point of the building to another far distant, often to waste valuable time in searching out a particular object if it happened to be in a small collection, and always with the drawback of having to carry in the mind's eye the quality, style, etc., of the sample with which comparison was to be made. Under such an arrangement of exhibits it became a matter of necessity to go over the collection of every country, and make a tour of every court, inspecting objects in which one took no interest, to make sure objects sought for had not been overlooked, so that in the case of a provincial or foreign visitor making but a limited stay at the seat of an exhibition, it became impossible to make a complete and satisfactory examination of any class of objects in which he took a studious or commercial interest. Beyond this, the distribution of space, to meet the requirements of great and small countries, the exigencies arising from the exhibits of some countries falling short and others exceeding the space calculated for, leads to the ground-plan of exhibitions so arranged becoming unmethodical, unsystematic, and difficult to comprehend or follow. The experience thus gained made it evident that a simpler system for distributing the exhibits of international contributors was a necessity if such collections were to serve the purpose of study, as well as those of mere display. Consequently, in the official programme for the Exhibition of 1871, we found it announced that "*The arrangement of the objects will be according to classes, and not, as in former International Exhibitions, according to nationalities.*" Unfortunately, this palpable move in the right direction was never properly carried out, except in the picture-galleries, departments for machinery in motion, and new scientific inventions, nor were

the new galleries adapted for carrying out the proposed arrangement, as the rooms devoted to educational appliances and porcelain, etc., were only large enough to hold the British exhibits, and would not have been large enough for that purpose had they been fully represented. Thus the Educational Department very imperfectly represented the appliances in use in Great Britain for teaching, especially in the section for Science and Art, many well-known firms being entirely unrepresented, while others only exhibited just enough to give their names a place in the catalogue. This is to be regretted, as a complete collection of the educational appliances of all nations arranged, as proposed, in one class, would have formed a most valuable and instructive collection; whereas the foreign educational collections had to be hunted out in various parts of the building, though the official catalogue led one to look for them collected together in one gallery—an opportunity lost, which, according to the arrangements laid down by Her Majesty's Commissioners for the annual exhibitions, will not present itself again for ten years to come.

If practical experience has taught us that *the arrangements* in past English exhibitions have proved defective, on the other hand, we have learnt a lesson as to what proved eminently effective and beautiful in the constructive details of such buildings; for who that visited the Great Exhibition of 1851 can ever forget Paxton's Crystal hive, suggesting a design begotten in a dream of fairy-land; a palace framed of spider's web, the interlacings filled with entangled films of dew; or the overpowering feeling a glance down the endless vista of that magnificent nave never failed to produce, a vista dotted with many a trophy of science, art, and manufactures; extending apparently to infinity, typical of the broad road that lies before inquiring man—a road that must be followed slowly, patiently, and with never-ending toil, but toil that never depresses, for the way is bathed in a golden flood of heaven-born light, and the heart will be lightened by a foregone conviction, that, however small a portion of that road can be traversed, there must be a proportionate gain, for it leadeth to an increase of knowledge;—who can have traversed that crystal vault without bearing away an undying recollection of *The Amazon, The Mourners, The Stuttgardt Horses, The Greek Slave,* the glorious roll of the huge organs, or the harmonious blending of colour, form, and light? If ever there was an embodiment of the poetry of architecture, it was in Paxton's Hyde Park edifice. The building of 1862 was wanting in grandeur, and was deficient in light, and the sculptures grouped in the nave were mostly hemmed in with incongruous objects. In the galleries erected for the proposed annual exhibitions, the space seems to be too much cut up to allow of the rule for the exhibitors of all nations of a given class of objects to be arranged in one unbroken series, so (as in 1871) there must be a return to the system of national courts and annexes. Provision for the pageantry of opening ceremonials, etc., connected with the exhibitions is utterly unprovided, though it was a natural conclusion that the Albert Hall—the finest building since the days of the Roman Coliseum for holding large assemblages of spectators—so closely connected with the galleries, would have been employed on such occasions. The Horticultural Society's conservatory proved quite inadequate as to space for the purpose of the opening ceremony of 1871, and the procession through the picture-galleries utterly unimposing as part of a state ceremonial, for the eye had no opportunity of taking in more than infinitesimal portions at a time, to say nothing of the lopsided, unsymmetrical aspect produced, through only one side of the rooms being devoted to the passage of the official walk round. The absence of music during this progress was another serious shortcoming. In the construction of a building to meet the requirements of any future International Exhibition on the scale of the English and French displays between 1851 and 1867, it will be obvious that provision should be made for a grand central hall fully lighted from above, wherein could be grouped the sculptures, the trophies of science, manufactures, and characteristic products of the various countries, embedded in a background of natural foliage, surmounted by the banners and armorial escutcheons of the nations of the world, to reproduce the *coup d'œil* that proved so eminently effective under Paxton's glorious nave, to which the harmonious colouring of Owen Jones added not a little. In a hall of such proportions there would be ample space for the proper display of the pomp and pageantry of state ceremonials, with their attendant processions, and for the suitable distribution of powerful musical instruments, such as organs, etc., over so vast an area, to provide against a repetition of the palpable shortcoming of 1871; for a procession without the accompaniment of stately march music always proves spiritless and tedious, and appears as incongruous as playing "Hamlet," and dispensing with the part of the *Prince of Denmark*. It is also obvious that the general plan of the building should adapt itself to a scheme of arrangement that should be simple of comprehension, and allow of objects of a similar character being brought together for comparison under CLASSES, without separating individual contributions from THE COUNTRY to which they pertain—an arrangement such that a visitor could, at will, examine a class of objects contributed by all the exhibiting nations, or only the collective contributions of a single country to a given class, and that within the range of one gallery, and without sacrificing national prejudices. Such a problem I attempted to solve in 1862, while experiencing the inconvenience of the higgledy-piggledy distribution of scientific objects in that year's Exhibition, and discussed in the first of a series of critical articles on "The Photographic Apparatus and Appliances at the International Exhibition," in *The British Journal of Photography*, Vol. IX., page 331, and I believe my scheme would be found to meet all the requirements. On each side of the central hall as many galleries as there are classes should be symmetrically arranged, extending, like parallel streets, the entire length of the building, but intersected at convenient intervals by passages, to facilitate easy communication between one part of the building and another—a matter of the utmost importance.

JAPAN.	UNITED STATES.	UNITED STATES.
CHINA.	BRAZILS.	RUSSIA.
CEYLON.	INDIA.	PRUSSIA.
INDIA.	PERSIA.	AUSTRIA.
TURKEY.	SIBERIA.	FRANCE.
RUSSIA.	GREECE.	BELGIUM.
SWEDEN.	RUSSIA.	
NORWAY.	SWEDEN.	
DENMARK.	DENMARK.	
PRUSSIA.	PRUSSIA.	
AUSTRIA.	AUSTRIA.	
SWITZERLAND.	SWITZERLAND.	
ITALY.	ITALY.	
SPAIN.	SPAIN.	
PORTUGAL.	FRANCE.	
FRANCE.	BELGIUM.	
BELGIUM.		
HOLLAND.		
GREAT BRITAIN	GREAT BRITAIN.	GREAT BRITAIN.
CLASS I. RAW MATERIAL.	CLASS IV. FOOD.	CLASS VIII. MACHINERY.

Fig. 1.

Each *Class Gallery* should be subdivided according to *nationalities*, and the space allotted to each nation should be just sufficient to contain its exhibits belonging to that particular class. So that each *Class Gallery* would be quite independent of those adjoining, and be arranged without reference to the space or exact locality any nation's exhibits might occupy in other class-galleries; the idea of forming national Courts for exhibits of varied character, such as we saw in the French Annexe in 1871, being ignored. This system of arrangement will be made clear by the annexed diagram (Fig. 1).

TECHNICAL DRAWING.—LIII.

GOTHIC STONEWORK.

POINTED ARCHES — TRANSITION DOORWAY — ROLL AND FILLET.

It has already been said that pointed arches were introduced during the latter part of the twelfth century. Before its close they were used in many varieties of form, from the barely-pointed or low "drop" arch to the acute lancet. Fig. 468 is a Transition doorway in the north wall of the ruins of St. John's Priory, Chester, in which will be seen not only the pointed arch, but the square abacus, to the now shaftless capitals. with the joining edges rounded off so that the fillet merges gradually into the roll, as shown in Fig. 471.

An example of the manner of placing this moulding in the Transition style is given in Fig. 472.

THE EARLY ENGLISH PERIOD.

This style, the first of the pointed arches, may, in general terms, be called the thirteenth century style, extending, on the whole, as it did from about 1180 to about 1300, including part of the reigns of Henry II., Richard I., John, Henry III., and Edward I.

The architecture of this period is exceedingly beautiful and

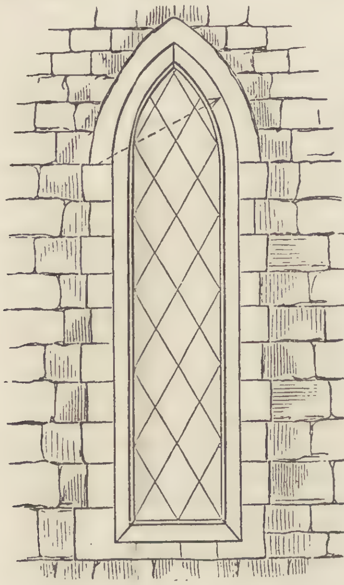


Fig. 473.

Fig. 471.

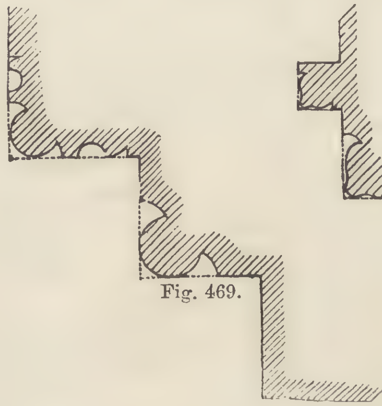


Fig. 469.

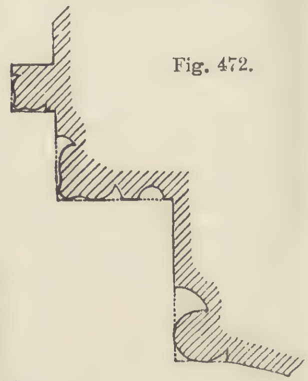


Fig. 472.

Fig. 470.

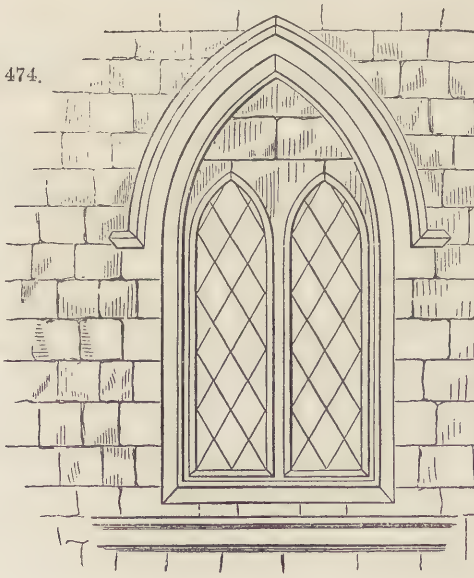


Fig. 474.

Fig. 468.

Fig. 469 is an enlarged section of the arch-moulding, from which it will be seen that the regular character of the several orders was still retained; but the mouldings cut upon them became more varied and numerous, and several new forms were introduced. In this figure the first order is plain, with the square edge; the second has the simple Norman edge-roll; but the third is of a more complicated character. The edge-roll has *two* hollows on each side, and the second has the sharp indented line carried round it.

The most important form, however, introduced during this period of transition was the "roll and fillet," a moulding which continued to hold a leading place in the combinations of all the succeeding styles. It may be described as a narrow band or fillet, set flat upon the face of the common cylindrical roll or bowtell. In the earlier examples it is mostly set square upon the round member, as in Fig. 470; but it is often found chaste; simple and elegant in design—excellent and delicate in execution; equally applicable to the modest village church and the noble abbey and cathedral; remarkable in the one for its unobtrusive simplicity, and in the other for its solemn and majestic grandeur.

"Nothing," says the Rev. J. N. Hutchinson, "could be more striking than the change from Norman to Early English. The two styles were the complete opposites of each other. The round arch was replaced by the pointed, often by the acute lancet; the massive piers by graceful clustered shafts; the grotesque and rudely-sculptured capitals by foliage of the most exquisite character; and the heavy cylindrical mouldings by bands of deeply undercut members."

The most generally used arches at this period were the acutely pointed, either lancet or equilateral. As a rule, the arches are comparatively more acutely pointed in cathedrals and

the larger churches, whilst the obtuse angles are most frequently used in the smaller churches.

The semi-circular arch had not entirely gone out of vogue, and at Whitby Abbey, and in other examples, we find it combined with the pointed, two or more of the latter being sometimes included under one of the former. There are also examples in which the semi-circular form is used alone. The soffits of the arches were, in the larger examples, richly moulded with a series of rolls and hollows in a manner which will be more explicitly referred to further on, but in buildings of a less magnificent character they were merely recessed in orders, the edges being simply chamfered.

The dripstones over doors or single windows follow the form of the arch; but where the windows consist of several separate lights—that is, where each window is made up of several others placed close together—the dripstone forms a sort of gathering arch over all. This seems to have led to the introduction of tracery, the progress of which will be illustrated presently.

The doorways of this period are very frequently furnished with nook-shafts, which are for the most part detached from the walls, except at the capitals and bases. The more simple doorways have only one shaft on either side, supporting an archivolt of a few bold mouldings. More elaborate specimens have two or more shafts on either side, and a greater number of mouldings in the arch.

The jamb is recessed in order to receive the shafts, and the spaces between the mouldings or their hollows are often filled up with an ornament called "the dog-tooth"—a leading type of the style—or a running pattern of foliage. A beautiful specimen of such a doorway may be seen in the ruins of Valle Crucis Abbey, near Llangollen, North Wales, where there is also a fine three-light window of a very large size, three lancet-headed lights being gathered under one dripstone. The doorways of the larger structures are mostly divided into two arched apertures by a simple or clustered shaft, which is often of polished marble with richly-carved or moulded capital. The arches are also foiled or foliated, the spandril between them being perforated in circles, trefoils, etc., and sometimes filled with foliage or groups of sculpture.

The doors themselves are either plain or covered with iron scroll-work, and sometimes with hinges, which are often of a very ornamental character, although at other times nearly plain. An excellent specimen of such iron-work exists on the doors of a vestment-closet in one of the small chapels in Chester Cathedral, and in the Chapter-house, York Minster. Very fine ornamental hinges, covering almost the whole door, may be seen at Eaton Bray Church, Bedfordshire, at St. Mary's, Norwich, etc.

EARLY ENGLISH WINDOWS.

One of the most interesting branches of the study of Gothic architecture is that connected with the history and progress of windows, marking as it does the gradual development from the most simple forms to the culmination in the grand tracery which characterises the windows of the next period; the increase of size and falling off in the graceful forms in the subsequent style; the flattening of the arch and consequent diminution of the tracery; and, finally, the decay of the whole system.

The windows of the style now under our consideration are, for the most part, long and narrow, with acutely-pointed heads (Fig. 473). The earliest and simplest form is that of a long, narrow, single light with arched head, and without moulding of any kind, either internally or externally, the exterior angle being merely chamfered, and the interior widely splayed.* Such windows were sometimes without any weather-moulding, but occasionally a string-course was carried from one window to another at a level with the springing of the head, and then lifted over it, adopting its form, and then carried on to the next aperture. As the period advanced, these windows were placed near each other, in groups of two, three, five, or more, the first being usually found in the sides of churches, and the latter at the east end, except in very large buildings, where it is found in all positions. It has been mentioned that where windows of more than one light were employed, it was a common practice to include them under one dripstone, the head of which was left plain. Such a window is shown in Fig. 474, and from this it will be seen how the introduction of tracery became necessary for the beauty and lightness of the form.

The next study is a view of a two-light window from the north aisle of Stoke Pogis Church, Bucks, drawn to scale of ½ inch to the foot (Fig. 475).

In this example the plan is to be drawn first, and the jambs and mullions should then be projected by perpendiculars drawn from the plan. The arches are rather lower than they would be if the distance from the springing to the apex were the same as the width of the lights. The centres therefore fall between the springings.

In this illustration it will be seen that the dressings of the window are tooled, whilst the wall is of coursed rubble, strengthened over the window by a relieving arch.

In drawing the various examples afforded by our present series of illustrations, care should be taken to render the work as sharp and clear as possible. The stone-work and the shading which it exhibits will be rendered best by a steel pen charged with Indian ink.

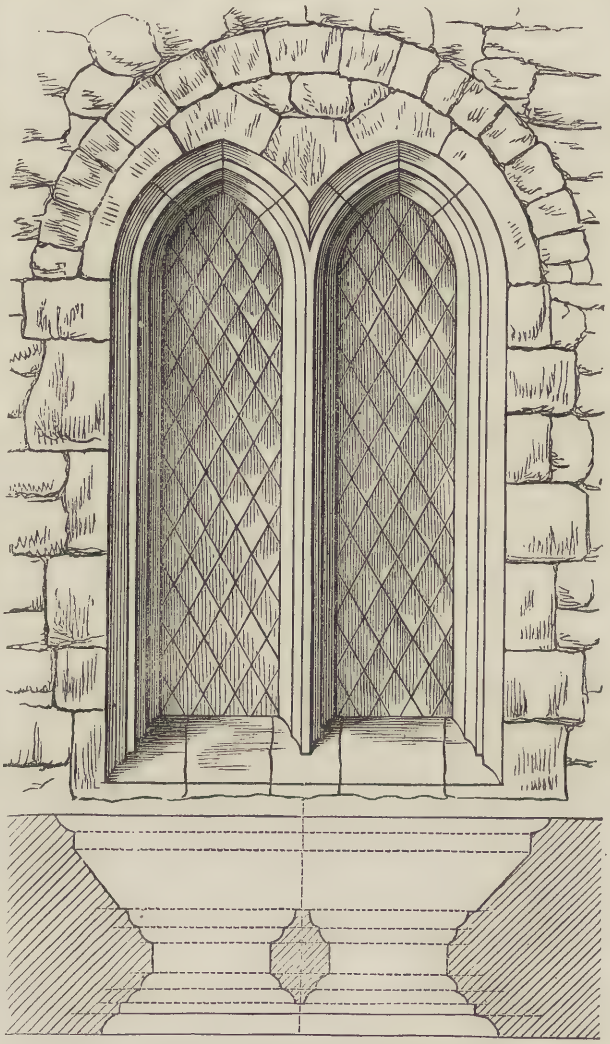


Fig. 475.—TWO-LIGHT WINDOW FROM THE NORTH AISLE OF STOKE POGIS CHURCH, BUCKS.

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* *Chamfer, Splay.*—Both these terms mean cutting away the edge of anything which was originally right-angled, so that instead of an edge, a slanting surface may be presented. A chamfer differs from a splay in being smaller, and usually cutting off equal portions from either side. It will be understood that by splaying the inner sides of narrow windows, the rays of light were permitted to spread, and thus the interior was better lighted.

NOTABLE INVENTIONS AND INVENTORS.

XXIII.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS" (*continued*).

BY JOHN TIMBS.

THE "Century of Inventions," by the Marquis of Worcester, has been described as "an amazing piece of folly" by a few shallow persons. It contains the description of one hundred inventions, of which those relating to the Water-commanding Engine have been described. Mr. Partington, in his edition of the "Century" published from the original MSS. in 1825, in an able series of notes, shows the practicability of the major part of the hundred inventions, and the application of many of them, under other names, to useful purposes. We quote the list of inventions, with such portions of certain of the notes as the space at our command will allow.

1. *Seals*, upon any of which a man may keep accounts of receipts and disbursements, from one farthing to one hundred millions, punctually showing each pound, shilling, penny, or farthing. By these seals, likewise, any letter, though written but in English, may be read and understood in eight different languages. The principle is, "A frame similar to those in which seals are generally mounted, and movable circles made to slide within each other on one common centre. If three are employed, they should be engraved with the numerals, the alphabet; and, if intended for secret writing, the third circle may be furnished with arbitrary signs. These, by means of a key, of which both the corresponding parties must possess a duplicate, may be combined to form the day of the week, month, year, etc."

2. *Seals, private and particular to each owner*, the deciphering depending on the smallest variation of the key.

3. *A one-line cipher.*

4. *Reduced to a point.*

5. *Varied significantly to all the* 24 *letters.*

6. *A mute and perfect discourse by colours.* A telegraph which must have nearly resembled that in use at the present period.

7. *Telegraph by night*, rockets or reflecting lamps being substituted for painted boards.

8. *To level and shoot cannons by night as well as by day*, without a platform or measures taken by day.

9. *A ship-destroying engine*, portable, to be fastened inside the greatest ship, and at any appointed day or minute, day or night, it will sink that ship; it being merely necessary to connect a gun-lock with a common bomb-shell, fitted in the usual manner, and a small clock attached, which will at any given time discharge the lock, and cause the shell to explode.

10. *How to be fastened from aloof and under water.* This engine resembles Fulton's torpedo.

11. *How to prevent and safeguard any ship by day or night.* "A strong net is to be kept at the required distance from the vessel by floating buoys; upon the upper extremity of each buoy is fixed a bell, which, by its ringing on a certain night, discovers the approach of any hydrostatic vessel; and should the weather be stormy, the attempt must end in the destruction of the submarine voyagers."

12. *An unsinkable ship.* A way to make a ship not possible to be sunk, though shot at a hundred times between wind and water by cannon; and should she lose a whole plank, yet, in half an hour's time, she could be made as fit to sail as before. The hull of the vessel to be composed of a number of small divisions, when it will scarcely be possible to sink it, especially if a sheet well prepared with oakum be drawn under the vessel in the event of a fracture, as the pressure of the water on the vessel's surface will force the canvas into the chasm; a method long adopted in the navy.

13. *False destroying decks*, to kill and take prisoners boarding the ship, without blowing the real decks up.

14. *Multiplied strength in little room.* How to bring a force to weigh up an anchor, or to do any forcible exploit in the narrowest or lowest room in any ship, where few hands shall do the work of many—by an endless screw or worm, to remain stationary at any point.

15. *A boat driving against wind and tide*, which, though directly opposite, shall force the ship or boat against itself. This is done by a globular windmill erected in the centre of a ship, for turning two wheels or paddles placed on the bows, which would impel the vessel forward in any direction that might be required.

16. *A sea-castle or fortification, cannon-proof*, to contain 1,000 men, yet suitable to defend a passage, or, in an hour's time, to divide itself into three ships. Bomb-proof batteries were used by the Spaniards in their attack on Gibraltar, in 1782; they resisted the shot and shell, until General Elliot, by red-hot balls, burnt through the outer layers into the hold used as a depository for powder, and thus destroyed this immense flotilla.

17. *Floating gardens upon the Thames*, with trees, flowers, banqueting-houses, stews for fishes, delicate bathing-places, music made by mills, etc. The floating pleasure bath, moored near Westminster Bridge, was supported by empty casks; and, says Mr. Partington, "this plan, if assisted by mooring-chains, may be applied to gardens of any reasonable extent, even in the broadest and most rapid extent." The Mexicans formed their floats by first plaiting or twisting willows, with roots of marsh plants, and upon this foundation they placed mud and dirt drawn from the bed of the lakes.

18. *An hour-glass fountain*, of which, when the upper division is exhausted, the lower may be elevated by a crank or lever, the fluid passing through the centre of its axis. The Marquis states that the water may produce snow, ice, thunder, and the singing of birds, but how is not explained.

19. *A coach-saving engine, within a coach*, whereby a child may stop it, by unloosing the coachman and horses.

20. *A balance water-work*, to bring up water by its weight within the buckets, which counterpoise and empty themselves into one another; the uppermost yielding its water, at the same time the lowermost taketh it in, though it be a hundred fathoms high.

21. *A bucket fountain*, to raise water with two buckets only, without any other force than its own motion.

22. *An ebbing and flowing river*, to work with a child's force. Bogaerts' canal-lock effects this object, in which a small portion of water assists in displacing several tons of the same, and there is no doubt but *a child's force* would raise double the quantity of water described by the Marquis. In the model a weight of seven pounds was made to raise 10 cwt. of water more than four feet in a few seconds.

23. *An ebbing and flowing castle clock*, showing the hours, minutes, and seconds, and the motions of the heavens, and counter-libration of the earth, according to Copernicus. The Marquis's astronomical machine must be provided with two barrels, each with sufficient maintaining power for the correct performance of the whole. In addition to the supporting line, each barrel has a revolving pulley, with chains passing over their axes, and attached to wood floats, alternately raised or depressed by ebbing and flowing of the tide, and thus winding up the clock.

24. *A self-increasing spring*, so as to shoot bombasses and bullets of a hundred pounds weight a steeple height, "admirable for fireworks and astonishing of besieged cities." Upon this, Mr. Partington notes: "The strength of a compound spring formed of two metals may, by the application of heat, be increased to any given power." *Rationale*: Iron possessing an expansive power $\frac{1}{95}$, and brass being only $\frac{1}{60}$, the weaker metal will be bent by that whose power of expansion is greater, and the impulse of the spring increased in equal ratio.

25. *A double drawing engine for weights.* "How to make a weight that cannot take up a hundred pound, and yet shall take up two hundred pounds, and at the self-same distance from the centre; and so, proportionally, to millions of pounds." Mr. Partington considers this paradoxical and unscientific, and regards it as one of the *marvels* which brought the whole "Century" into disrepute.

26. *To and fro lever.* To raise a weight so well and as forcibly with the drawing back of the lever as with the thrusting it forwards; and by that means to lose no time in motion or strength. This the Marquis saw in the Arsenal at Venice. It is the mere application of a crank.

27. *A most easy level draught.* A weight attached to an ordinary crane.

28. *A portable bridge.* The apparatus, to be attached to the banks of a river, consists of two ropes or wires, tightened by a winch, on which slide pulleys connected with a large floating tank or wagon. The communication is effected by means of two cords between the opposite banks of the river.

29. *A movable fortification*, "to contain 500 fighting men, yet, in six hours' time, to be set up and made cannon-proof upon the side of a river, with cannon mounted upon it." This Mr. Partington does not attempt to elucidate.

30. *A bulwark* to be raised in one night, twenty or thirty feet high, cannon-proof, and cannon mounted upon it; with men to overlook, command, and batter a town; and with but four pieces to discharge 200 bullets each hour. Upon this Mr. Partington notes the effects of highly elastic vapour propelling leaden bullets, by Perkins's "Steam Gun;" and these engines can discharge nearly 200 bullets in one-sixth part of the time described by the Marquis of Worcester in the above article.

31. *Blind* for approaching a castle and town wall and ditch. A strong wheel carriage and heavy iron tower, hung round with sand-bags; the tower to be moved by handles fixed to the axles of the wheels, to be turned at pleasure by those within the walls. Nearly similar machines are described by Vitruvius.

32. *A universal character*, "methodical and easy to be written, yet intelligible in any language; so that if an Englishman write it in English, a Frenchman, Italian, Spaniard, Irish or Welshman, being scholars, yea, Grecian or Hebridist, shall as perfectly understand it in their own tongue, as if they were English, distinguishing the verbs from the nouns, the numbers, tenses, and cases, as properly expressed in their own language as it was written in English." Mr. Partington's note extends to six pages, sketching the various contrivers of a numerical character, and quoting memoirs of Francis Bacon, Descartes, Becker, Dalgarno, Frisichius, Kircher, and Bernier. But the most remarkable work is that of Bishop Wilkins, whose real character is supposed to strongly resemble that of his contemporary, the Marquis of Worcester. The bishop explains the signs which are to be used to denote all the principal ideas, the relative attributes being designated by small strokes added at right, acute, or obtuse angles, to the right or left, etc. He admits chief ideas, forty in number, under which he ranges all the others by a series of categories. Leibnitz's "Universal Language" is generally known: he considered his characteristic as the art of inventing or judging; he was convinced that an alphabet might be formed, and of this alphabet such words as would afford language capable of giving mathematical precision to all the sciences.

33. *A needle alphabet.* (See 75.)

34. *A knotted string alphabet.* "This very ingenious mode of *secret writing*," says Partington, "is the most simple of any suggested by our author. A silk string of considerable length furnishes the persons corresponding with a key, or graduated gauge, by means of which the writing will be rendered intelligible. Having procured a duplicate or corresponding gauge, it may then be commenced, $\frac{1}{16}$ of an inch being allowed for the first letter, $\frac{1}{4}$ for the second, $\frac{3}{8}$ for the third, and so on, in equal proportions, through the whole alphabet."

35. *A fringe alphabet.* "The principle of this and the four following articles," says Partington, "is the same as the preceding, with this difference, that in the first, the letters or words are formed by knotting the fringe, to which the gauge is afterwards applied; in the second and most durable way, the beads are set to the required distance; by the third, the gloves are pierced or pricked in rows, according to the divisions on the gauge; and by the fourth and fifth, the rows of parallel holes in a sieve or lantern are stopped at the required distances, and the gauge applied as before."

36. *A bracelet alphabet.*

37. *A pinked glove alphabet.*

38. *A sieve alphabet.*

39. *A lantern alphabet.*

40. *An alphabet by the smell.* Pegs of sandal, cedar, and rosewood may be so varied, that a person writing in the dark will, by the smell, readily distinguish the formation of words and sentences.

41. *An alphabet by the taste.* Immerse an equal number of the pegs or beads in weak solutions of alum, aloes, common salt, or any other liquid whose taste is sufficiently pungent or aromatic to be distinguished when dry, on applying the tongue to them for that purpose.

42. *Alphabet by the touch.* By these three senses, as perfectly, distinctly, and unconfusedly, yea, as readily as by the sight. The object (says Partington) may be readily attained by the use of raised movable types and the heavy pressure of an iron pen or mallet. A mode of corresponding by the touch has been suggested by M. Haüy, and by this means the blind have been fully instructed.

43. *How to vary each of these*, so that ten thousand may know them, and yet keep the understanding part from any but their correspondent. This may be effected by changing the order of their arrangement, which can only be ascertained by a previous examination of a key chosen for that purpose.

44. *A key pistol.* To make a key of a chamber door, which to your sight hath its wards and rose-pipe but paper thick, and yet at pleasure, in a minute of an hour, shall become a perfect pistol, capable to shoot through a breast-plate, commonly of carabine-proof, with prime, powder, and fire-lock, undiscoverable in a stranger's hand. The *pipe* must, in this case, be formed like the sliding tubes of a telescope; that next the wards being furnished with a screw at the inner end, capable of holding the whole of them together. A small quantity of detonating powder being first placed within, the pipe may be readily discharged by tightening of the screw.

45. *A most conceited tinder-box.* How to light a fire and a candle, at what hour of the night one awaketh, without rising or putting one's hand out of bed; and the same thing to be a serviceable pistol at pleasure. The pistol tinder-box (says Partington) may be readily made to perform the whole of what is here described. A bell-rope attached to the trigger will suffice to elicit fire, which, communicating with a quick-match or fusee, will quickly ignite and produce the required light. If the fire is previously prepared with wood or other combustible material, and inflammable spirits sprinkled over it, the slightest spark will throw the whole into a blaze. Of the latter qualification mention is made by the noble author, a piston barrel may easily be secreted under the tinder. The inflammable air-lamp, contrived by Volta, possesses similar properties; a stream of hydrogen gas being inflamed by the spark of an electrophorus. For information on this subject, see Brande's "Manual of Chemistry," Vol. I., p. 240.

46. *An artificial bird* may be made to fly, which way and as long as one pleaseth, by or against the wind, chirping or hovering. In the year 1810, two birds were exhibited at Merlin's Museum; they performed all the evolutions described by the Marquis of Worcester.

47. *An hour water-ball* may be made of any metal, which, thrown into the water, presently rises from the bottom, and shows by superficies of the water, the hour of the day or night, just to the minute it showeth of each quarter of an hour. "A metal ball," says Partington, "graduated on the surface, in the same manner as the index stem to an hydrometer, with a balance to preserve its equilibrium, must first be exhausted of air, when the water may be made to enter by a small aperture, and it will gradually sink till the vessel is filled; this, if the ball is about twelve inches in diameter, and the aperture of a proportionate size, will not take place in less than twelve hours."

48. "*A screwed ascent of stairs*, with fit landing-places to the bed-chambers of each storey, with back stairs to the *nod* of it, convenient for servants to pass up and down to the inward rooms of them, unseen and private." It is most probable (says Partington) that the Marquis here alludes to the geometrical staircase now in such general use, with the addition of a small flight of stairs in the centre, in lieu of the common hand-rail, which, being surrounded by a partition of boards, would serve as a private communication with the upper storeys; sufficient space being left between the ceiling and upper side of the principal staircase to admit of a passage to the inner rooms.

49. *A tobacco-tongs engine*, whereby a man may get over a wall, or get up again, being come down, finding the coast proveth insecure for him. By tobacco tongs is supposed to be meant a combination of levers, jointed together; when by distending the lowest arms horizontally it may be made to go in the smallest compass; while by closing them the machine will be elevated. A *fire-escape* has been constructed upon this principle.

50. *A pocket ladder*, fastened a hundred feet high to get up by from the ground. This consists of light brass tubes, each having a socket to receive the end of the preceding joint, to be raised to any given height.

51. *A rule of gradation*, which, with ease and method, reduceth all things to a private correspondence, most useful for secret intelligence. (See article 5.)

PRACTICAL APPLICATION OF THE FINE ARTS.—VI.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

In Figs. 10 and 11 we have progressive examples of the principles that we have expounded before. These are two stages of the same work. Note, to begin with, that we give a face in which we intend to convey the sweetness and expression of the old painters, combined with the improved drawing of the nineteenth century. This is perhaps as important a lesson as we can convey to the student of the present day—more valuable by far than any mere directions as to the mechanical execution of the work, because it refers to the cultivation of the taste, the education of the mind, and the elevation of the aim, rather than the instruction of the hand or the adaptation of the means. There is good in the old and in the new. The ancient aimed at elevation of thought-feeling. In representing a Madonna, he would try to suggest notions of purity, of love, of feminine delicacy, and the like; he would wish his picture (or window) should be a sermon when no priest was at hand to preach, a book to those who knew nothing of letters. At the same time he was ignorant of anatomy, he had but little knowledge of the nude figures; the artist was a monk, not a spectator of the gymnastics of Greek athletes. His knowledge of foreshortening was empirical, and atmospheric effects he had no means of representing. Consequently, his drawing was extremely bad in many good pictures, and foreground and background were in inextricable confusion. Knowing but very little on these subjects, but feeling strongly about others, in some respects he was excellent, in others he is far excelled by the moderns.

Fig. 10.

Fig. 11.

Fig. 11 represents the first stage of a somewhat elaborate portion of a picture. Naturally more labour and care will be expended upon the heads in a picture than upon any other portion. We have already spoken of carefulness of design; but unless there is very careful elaboration of the design, the latter will be liable to be spoilt in the manipulation. The glass upon which heads are executed is usually smoother, and more free from air-bubbles, than that intended for draperies and other coarser portions. There is a certain latitude, too, of tone; for the heads of men a deeper colour will naturally be employed than for delicate female heads. It should be remembered in the choice of glass, that the colour of the material should not exceed that of the lightest portion of the design. The glass may then be placed on the paper on which the charcoal drawing has been made, and with a long sable brush, No. 2 (Vol. II., p. 304), the whole of the outline of such a design as Fig. 11 may be traced in with the enamel mixed with water. This is one of the advantages of the glass that the design may be traced through, though it will be found necessary afterwards to suspend the glass on a frame, so that it may be clearly seen if any parts are omitted, and to correct any mistakes or harshness of outline that might result from the former process. We all know what is the appearance of a child's so-called transparent-slate, and the harsh drawing that is drawn thereon. This, of course, is to be avoided; but at the same time the transparency can be made available for getting in the larger and coarser outlines. When the result is satisfactory the whole may be left to dry, and may even be sent to the oven to be burnt in. It is, however, better to avoid more burnings than are absolutely necessary, and the most satisfactory glass generally is that which has been burnt but once.

The first outline being fixed, we go on to the additional shading in Fig. 11. Down the right-hand side of the face the slightly curved lines marked A are intended to represent a smudge, or stipple shading, which is laid on with one of the larger camel's-hair brushes (No. 1), and then dabbed with the point of a hog's-hair tool (No. 5). The deeper outlines will be a guide for a good portion of this work, but some will have to be shaded off. This latter process is best accomplished by carrying the shade a little beyond the place at which it is intended to stop, and then when it is dry rubbing off a portion with No. 3 or 4. It will be observed that the shade spreads not only on the face and neck, but also on a portion of the hair—that part, namely, nearest the face and neck. The straight horizontal lines, B, across the hair and top of the dress are intended to represent a yellow stain, which has to be applied to the glass independently of the enamel shade; but it should be put on before the first burning. This may be effected by putting the silver on the back of the glass whilst the enamel is on the front.

When this has been completed, it will be found advisable probably to deepen some of the outlines, and to make the lines of the hair and drapery bolder, and better defined. This may be done with the oxide mixed with oil or turpentine. It must be remembered all through that the oxide is apt to come out a little less dark than it appears before it goes into the oven; but that, on the other hand, the shading on the flesh and other light portions is much more perceptible than on the darker and deeper colours, and therefore should be kept lighter.

SHIP-BUILDING.—V.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF WOOD SHIPS.

In accordance with the intention previously expressed, we will now begin our examination of the structural arrangements of ships at the framing, afterwards passing on to notice the skins and decks. In order to economise space, we shall deal briefly with the arrangements of keels, stems, stern-posts, and other pieces closely connected with the framing, while speaking of the latter.

"timber and space," and this distance would be fixed in the specification of the ship. The origin of the term is obvious, seeing that the timbers of the frame do not touch those of the filling-frame, a "space" or "opening" being left between them. Taking the frame first, it is seen to consist of a "floor," which crosses the keel, and has arms of equal length, ending on either side at the "floor-head" (marked F H in the figure). Upon the butt or end of the floor is fixed another timber, known as the "second futtock," and ending at the second head (marked 2 H); and upon this timber comes another, named the "fourth futtock," ending at the "fourth head" (marked 4 H); and so on. The corresponding arrangement in the elevation will be seen under the bracket marked (1).

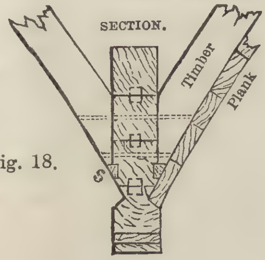


Fig. 18.

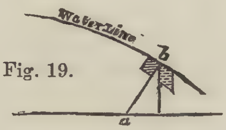


Fig. 19.

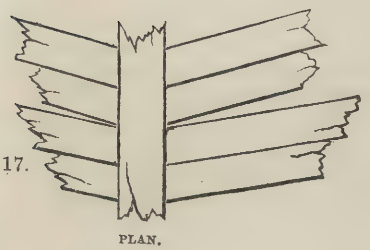


Fig. 17.

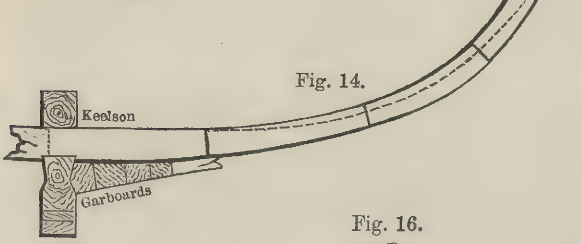


Fig. 14.

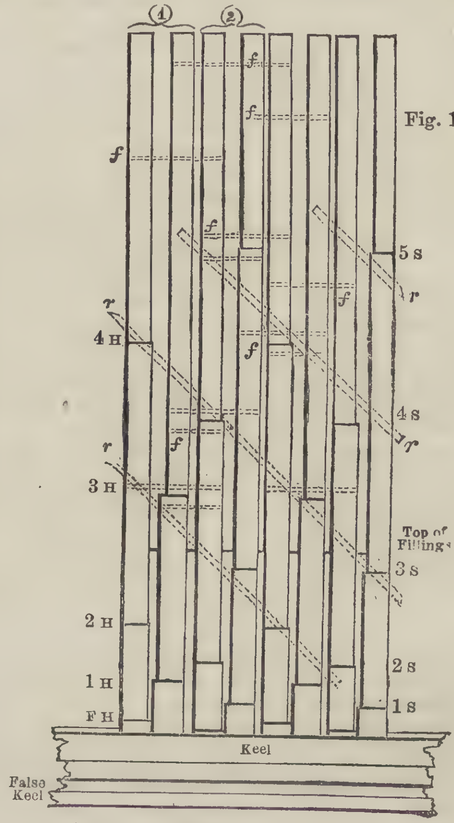
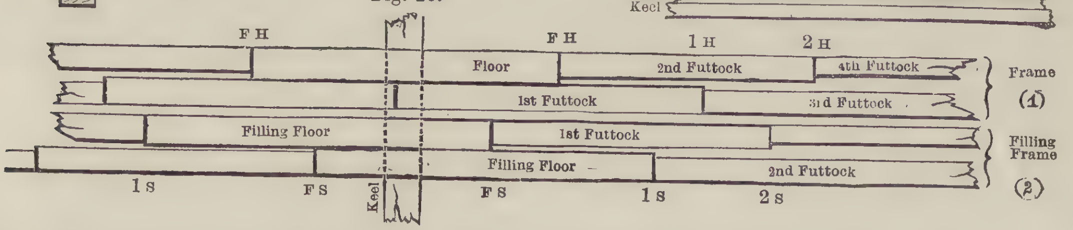


Fig. 15.

Fig. 16.



Wood ships have their frames arranged on different plans, but in all of these the great features are the same, and the differences existing are comparatively trifling. In all cases the curved frames are each made up of several solid timbers, joined to one another by one of the methods illustrated in Fig. 6, page 29; but different builders follow different plans in arranging the joints, as well as in securing them. Instead of attempting to follow out these plans in detail, we will select a good arrangement, and endeavour to show the principles upon which it is based, as well as to point out its distinctive features. Figs. 14, 15, 16 show such an arrangement in section, elevation, and plan, and we may add that it illustrates the system of framing usually followed in the Government service when wood ships were in vogue.

On reference to the plan (Fig. 16) it will be seen that the four timbers shown are bracketed in pairs, and named "frame" and "filling-frame." The distance from the centre lines of these two combinations is technically termed the "room and space," or

The second set of timbers in the frame consists of "first futtocks" butted near the centre line of the keel, and extending out to the "first head" (marked 1 H); upon which come "third futtocks" ending at the "third head" (3 H); and so on. The sides of the adjacent floors and first futtocks are accurately fitted together, and these timbers are fastened to each other by dowels and bolts, so that the floor forms a strap to the butt of the first futtocks. The timbers above the floors and first futtocks are not, however, close-jointed in the case before us, and as they are of less "siding" (that is, smaller in the fore-and-aft direction) than the floors and first futtocks, "openings" are left, as shown in the plan and elevation. It will also be seen from the drawing that the butts of the two sets of timbers in a frame are made to "give shift" to each other; that is, the butts of one set are so placed as to be near the centres of the lengths of adjacent timbers in the other set: the advantage thus gained will be obvious.

Turning to the "filling frame," (2) quite another kind of

combination presents itself. The butts of the timbers are here termed "sirmarks" instead of "heads," and are marked 1 s, 2 s, and so on. They are, it will be noticed, made to give shift not only to each other, but also to the butts of the frame-timbers. Beginning at the keel, we find a pair of "filling-floors" close-jointed to each other; these differ from the "floors" in having a long arm on one side, and a short arm on the other. Hence they are sometimes termed "long and short arm floors." The long arm of one filling floor is on the same side of the keel as the short arm of the other, and the two timbers are fastened to each other by coaks and bolts in the parts between the "floor sirmarks" (F S). The "futtocks," or lengths of timbers, are usually numbered on the principle shown on the plan shown in Fig. 16; the first futtock having its upper end at the second sirmark (2 s), the second futtock at the third sirmark (3 s), and so on. In this particular of nomenclature, however, no uniform rule is followed, and it is really a minor matter.

The elevation in Fig. 15 shows that on the line drawn through any particular head or sirmark there are always found *three* passing timbers between consecutive butts, and the arrangement described above of alternate frames and filling-frames is adopted in order to secure this result, and at the same time to assist the conversion of the timbers. Formerly in the Government service it was, and still in the merchant service it is, the practice to have frames only, no filling-frames being fitted, and as a consequence only *one* passing timber is found between consecutive butts on any "head-line." In some cases this disposition is carried out on the basis of the "floor and first futtock" combination, and in others on that of the "long and short arm floor" combination, with minor modifications that need not be described; but in all cases it is desirable when this plan is followed to have good lengths of timbers in the frames, in order to secure good shifts of butts in adjacent timbers.

In comparing an arrangement like that in Fig. 16 with one where no filling-frames are used, it is necessary to remember that the timbers of the frame are not easily procured, because of their size and curvature, and that no single set of timbers forming a continuous "bend" from keel to gunwale (like that shown in the section) has in itself the power to maintain its form. The first consideration is one connected with what ship-builders term the "conversion" of the material—in other words, its shaping from the rough log, and it is a most important one; and as the floors are the most difficult timbers to procure, it appears probable that from this point of view the arrangement of Fig. 16 is preferable, because it is easier to convert long and short arm floors than floors with arms of equal length. Besides this fact there is another which has to be borne in mind—viz., that the provision of *three* passing timbers between consecutive butts instead of *one* renders it possible either to reduce the lengths of the individual timbers while retaining the same amount of strength in the framing, or, keeping the same lengths of timbers, to add to the strength of the framing. In fact, an intermediate course may be followed if desired, and advantages gained both as respects ease and cheapness of conversion and strength. Greater freedom in making his arrangements of the futtocks is undoubtedly given to the builder by the more recent plan; and the fact that it has entirely supplanted the other in the Government service furnishes valuable support to its claims to superiority.

Considering the strength of a set of timbers, like those shown in the section in Fig. 14, to resist change of curvature—and excluding for the time all the aid given them by the skin and other parts of the finished structure—it is obviously but small; no matter whether the timbers have square butts with dowels (as shown by 1 in Fig. 6, page 29), or angle-chocks (as shown by 3 in that figure). The former plan, it should be stated, is now almost universally adopted in the wood ships of the Royal Navy, while the latter is often used in merchant ships. Scarfs, like 2 in Fig. 6, are only used in special cases: for example, where it is desired to give great strength against strains in the direction of the length of the timbers, such as occur in wake of the chain-plates to which the shrouds are secured. But while weak when taken alone, the "bends" of timbers, when well combined with those adjacent to them, can be made comparatively strong, and capable of maintaining their form. One of the means adopted for connecting the frames, and enabling them to give mutual aid, consists in the use of what are termed "frame-bolts," of which examples are shown by *f*, *f*, in the elevation in Fig. 15. These bolts are generally of square iron, and are driven fore and aft through two or more timbers, being placed so as to clear the skin-fastenings as much as possible. In the case illustrated, the heels of the timbers are secured to the timbers on each side of them, while the heads are secured to one of the adjacent timbers, usually to the other timber of the frame or filling-frame. Near the upper ends of the timbers the frame-bolts are longer, and form a tie to a greater number of timbers. In ordinary merchant ships it is customary only to make the frame-bolts pass through the two timbers of a frame, and not to make the connection extend to adjacent frames, except in special cases. The difference between the two plans of bolting is not of very great importance, but the advantage undoubtedly lies with the plan which ties most timbers together: this is termed "chain-bolting."

To develop the strength of the framing to the fullest possible extent, the timbers of the respective frames and filling-frames must, however, be directly connected to each other. The older plan, still followed by the French, is to fit the timbers of the respective frames with close joints, and to connect them strongly by means of dowels and bolts, just as the floors and first futtocks are usually secured. This plan, of course, renders the openings between the adjacent frames wider than they would be on the other system, but this is of little importance, whereas in point of strength the framing is much improved. Recently the practice has been revived in this country, and as a proof of its advantages it may be stated that frames so arranged can be lifted bodily into place instead of being built up timber by timber. Of course more work is entailed by the close-jointing, dowelling, and bolting, but all this work can be done with facility while the frame is lying on the ground, and the advantages gained probably counterbalance the additional work. The butts of each timber are then directly supported, or strapped by the timber fitted or "fayed" against it; and when hoisted into place the frames can, if desired, be quite as well chain-bolted to adjacent frames as they can be on the ordinary method.

Little need be said respecting the manner in which the frames are secured to the keel and keelson. It has already been stated that great care is taken to connect the several pieces forming the keel, and a sketch of the kind of scarf adopted has been given in Fig. 7, page 30 (scarf with tabling). From the sectional view in Fig. 14 it will be seen that the floors are "let down" a little over the keel; this being usually done by cutting away the keel for half the amount, and the floor for the other half. In the case of the filling-floors a similar plan is followed for at least one timber, but the whole amount by which the floors are "faced" or let down over the keel is usually cut out of the first futtocks. The latter are butted a little on one side of the middle line of the keel, and by this means room is obtained to place a dowel in the timber in order to secure it firmly to the keel. A dowel is also placed in the "seating" of one of each pair of floors, where it crosses the keel; and in the upper surface of the other filling-floor a dowel is fitted to connect it with the keelson, a similar connection being made between each floor and the keelson. Bolts are also driven through the keelson, floors, or filling-floors, and keel to strengthen the connection.

Keel, framing, and keelson are thus firmly combined. The keel projecting from the bottom enables the vessel to find a continuous support when building, or when docked, and aids slightly in checking her rolling or drifting to leeward when afloat. The false keel, fitted in two pieces, is only lightly secured to the keel proper, so that it may be easily detached without injury to the ship if she strikes the ground. Structurally considered, the keel forms a longitudinal piece of the framing, and in this respect it is aided by the keelson, which also is of service in receiving the heels of the pillars supporting the deck-beams.

The thick planks, marked "garboards" in the sectional view in Fig. 14, deserve separate mention here, although they are not always, or often, fitted in merchant ships. One advantage of fitting them will be obvious at a glance—viz., that the floors required are of less depth near the keel, and are less faced down upon the keel than they would be if the same outside form were retained, and the bottom planking made uniformly thick down to the keel. In addition to this the garboard strakes are valuable as strengthenings to the lower part of the ship, being efficiently fastened to each other as well as to the frames and the keel.

Throughout the greater portion of the length of a wood ship, the system of framing would be identical with that described, the only changes being those due to alterations in the forms of

the transverse sections. Near the bow and stern, however, where the ship becomes rapidly narrower, and the water-lines are (as shown by the half-breadth plan in Fig. 12, page 61) far from being parallel to the middle line of the ship, it becomes necessary to make considerable changes. Instead of retaining the transverse position which all the amidship framing has, the frames are "canted," so that they may stand nearly square to the water-lines, and not require much "bevelling." This will be seen at once on referring to the sketch in Fig. 19, the drawn lines in which show the section of the canted timber (of which the line *a b* is the "stand"), and the dotted lines the form of section that would be required if the frame stood transversely. Although canted in the transverse sense, the frames remain vertical; in fact, the change of position will be clearly understood when we say that it is exactly that which would take place if the transverse frame shown in the sectional view in Fig. 14 were made to swing round a little about the middle line. The amount by which the timbers are canted, of course, increases as they approach nearer to the extremities; at first the departure from the transverse direction would be scarcely appreciable, but at the extremities it would be very considerable.

With cant-timbers it would obviously be difficult to continue the system of floors and filling-floors; and it would be practically impossible to do so when they are much canted. For example, the plan in Fig. 17 shows that the corresponding cant-timbers on opposite sides of the keel, being equally inclined to the keel, could only be formed out of a very large piece of timber, and that it would be folly to make the attempt. Besides this, there is the fact that near the extremities the vertical sections of a ship become more or less V-shaped, as shown by the section in Fig. 18, so that, irrespective of the canting of the frames, it would be most undesirable to endeavour to make them cross the keel. The ship-builder makes no such attempt, but by a very simple arrangement provides sufficient strength, as well as comparatively easy forms for the conversion of his material. In some cases, one or more "cant-floors," as they are termed, are fitted, but their use is not common.

Where the transverse frames end, or in technical language where the "square body" terminates, the space between the keel and keelson is filled by a longitudinal timber, strongly fastened by dowels and bolts to both, and forming the commencement of the "deadwood." This deadwood increases in depth as the extremities are approached, and has to be made up of two or more pieces in depth; consequently care has to be taken, not only in disposing its scarfs (which are plane) in relation to the scarfs of the keel and keelson, but also in bolting and dowelling the various parts in order to form a compact mass. The cant timbers heel against the sides of the deadwood (as shown in Fig. 18), and are dowelled and through-bolted to it. As the sections become more and more V-shaped, the heeling of the cants becomes deeper, but in no case should a sharp lower edge be left to the heel, and it is usual either to fit a "stepping piece" (marked *s* in Fig. 18), or to let the heels slightly into the deadwood in order to prevent this. When the plank is brought on outside all, additional fastenings are driven in the heels of the cants.

The disposition of the various heads and sirmarks in the square frame is carried out also in the cant bodies, where the timbers are arranged in pairs constituting frames and filling frames, with a common centre line or "moulding edge" to each pair. Near the extremities, where the ship's form is fine, and the girths of the frames are very much less than they are nearer amidships, it is customary to omit some of the butts, and to have what are termed "double-futtocks," that is, single timbers running between heads or sirmarks, which would be so far distant at the midship section as to require two timbers or futtocks between them. The lower water-lines are also much finer than the upper ones, and consequently the space to be filled by the lower cant-timbers is much less than that spread over by the upper timbers of the same number of frames. Hence it is necessary to have the lower timbers close-jointed, and to reduce their siding considerably.

The cant-frames of the fore body extend right forward; between the foremost cant and the stem, it is usual to fit a single timber, called the "knight-head," another termed the "stem-piece" being occasionally fitted in large ships. The foremost boundary of the structure is the stem itself, which in most cases has considerable curvature, and consequently has to be formed out of several pieces of timber joined by scarfs; the lower piece being scarfed to the foremost end of the keel, by what is termed a "boxen scarf." Within the stem, and closely fitting against it, lies the "apron"—a sort of inner stem of which the scarfs are carefully shifted with respect to those of the stem, in order that the two pieces may mutually support each other. The lower end of the apron is generally scarfed to the deadwood, of which it thus forms a continuation similar to that of the keel by the stem. In large ships further strength is given to the bow by means of the "stemson" fitted inside the apron, and connected with the foremost end of the keelson. The mass of timbering thus formed is fastened together by numerous dowels and through-bolts; and it is further secured to the framing on either side of the bow by means of strong breast-hooks, crutches, etc., stretching from side to side, and bolted to the timbers. The deck framing also forms a strong connection between the two sides, and altogether the arrangements made are, in well-built ships, as satisfactory as they can be with wood as the material used. It will be seen, however, that in iron ships no such elaborate combinations are required as the deadwood, apron, stemson, etc., of a wood ship.

Respecting the after-body, little need be said. The cant-frames usually end at or near the stern-post, although in some cases they extend around the stern also. The stern-post of a wood ship usually consists of several timbers strongly fastened together by tabling and through-bolts. The lower part, or heel, of the post is generally connected with the keel by means of mortises and tenons, and by diagonal bolts driven through the deadwood, post, and keel. The upper part of the post is secured to the counter-timbers, and in some cases to the deck-beams also. All these connections are, however, matters of detail, and they depend largely upon the character of the vessel, whether she is a sailing ship, a paddle-wheel vessel, or a screw steamship. If a screw steamship, she would probably have two stern-posts, with the propeller placed between them, and the rudder hung to the after post; in either of the other cases there would only be one post, to which the rudder would be hung. The after-ends of the timbers forming the deadwood are tenoned into the post, and a similar plan is followed with the keelson. Sometimes the latter connection is strengthened by a stemson, corresponding to the stemson at the bow. Iron hooks and straps are used here also to assist in uniting the two sides.

The outlying part of the stern abaft the post varies considerably in form, and also in the character of its framing. Much has been said and written respecting the stern framing of wood ships, and it is a matter requiring care on the part of the ship-builder; but it has little to do with the strength of the ship as a whole, and therefore only a few words can be said respecting it here. In square-sterned ships, "transoms" (or timbers lying almost horizontally) are commonly used, in combination with other vertical or oblique timbers of which the sides stand fore and aft. In ships with elliptical sterns, the stern-timbers are really "double cants," their sides lying in planes inclined both to the vertical and the horizontal. In other cases, as was said above, the whole stern is framed with ordinary cants. Whatever plan of framing is adopted, means have to be provided for strongly tying the overhanging stern to the main framing. A favourite means of doing so is by using iron riders, or tie-plates, which reach round the stern-frames on the outside, and stretch forward over the cant-frames, being bolted to all the timbers they cross. On the decks also iron tie-plates are sometimes fitted, and inside the frames crutches and hooks of various kinds are placed to strengthen the connection. In screw steamers especially is it necessary to strengthen the stern to resist the strains caused by the propelling apparatus; and this object is best accomplished by means of iron strengthenings, examples of which may be given hereafter if space permits.

FARMING AND FARMING ECONOMY.—VIII.

By Professor Wrightson, Royal Agricultural College, Cirencester.

THE CEREALS: WHEAT.

Botanists are not agreed as to the original parent form of any one of our cereals. Mr. Darwin, after boldly facing this difficult question through several pages of his "Animals and Plants under Domestication," writes: "Finally, every one must judge for himself whether it is more probable that the several forms

of wheat, barley, rye, and oats are descended from between ten and fifteen species, most of which are now unknown or extinct, or whether they are descended from between four and eight species, which may have either closely resembled our present forms, or have been so widely different as to escape identification." Could any summing-up be less satisfactory? That wheat has been cultivated from the most ancient times, may be proved from many passages in the Bible, and by evidence gathered from the lake habitations of Switzerland, where wheat was well known when men employed only flint tools.

According to Vilmorin, the cultivated wheats may be classified under seven species :—

Triticum sativum, both bearded and beardless, with many red, white, and yellow sub-varieties.

Triticum turgidum, with simple and with compound ears, and red, white, or intermediate sub-varieties.

T. durum, with three varieties.

T. polonicum, consisting of one type only.

T. amyleum, consisting of one type only.

T. monococeum, consisting of one type only.

T. spelta, with a bearded and a beardless variety.

T. sativum embraces all the varieties cultivated in this country, with the exception of some coarse large-yielding sorts known as cone-wheats and Egyptian wheat. The number of kinds of wheat is very great. Dalbret cultivated during thirty years from 150 to 160 varieties, Colonel Le Couteur possessed upwards of 150, and Phillipar 322. The number of sub-varieties appears capable of unlimited extension, since not only each ear, but each grain of special character is, according to Colonel Le Couteur, able to transmit its peculiarities, and originate a sub-variety with more or less fixed character. These varieties differ from each other in the colour, form, weight, or quality of the grain; the shape of the ear, some being square, while others are cylindrical, compressed (flattened), or tapering; in a closer or wider arrangement of the florets; in being bearded or beardless; in the roughness or smoothness of the chaff scales; in the length, strength, and hollowness of the straw; in the breadth of the foliage; in habit of growth, some being upright while others are more recumbent, and in their hardihood and adaptation to peculiar conditions of soil and climate. The following tables of the principal varieties, with their leading characteristics, contain some of the principal wheats cultivated in this country.

I.—WHITE BEARDLESS VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
A 1.		Rough.	Short.	Fine and plump.	
Brodie's.			Medium.	Fine, plump.	
Chiddam.	Square.		Long, stiff.	Short, compact, fine, plump.	Adapted for soft, good soil.
Corners.	Square.	Rough.		Fine, plump.	
Cluster, dwarf.	Compact, thick.		Short, stiff.		For rich soils.
Dantzic white.	Moderately compact.	Thin, smooth, white.	Tall, slender.	Oblong, translucent.	Obtained by Col. Le Couteur.
Earl Ducie's.	Square.	Smooth.	Medium.	Good quality.	
Essex.	See Chiddam.				
Fenton.	Square, upper florets slightly awned.	Smooth.	Short, stiff, unequal in length.	Pale, white, round, plump.	For rich soils.
Hallett's.	Square heads.	Rough.	Medium.	Fine, plump.	Improved by selection.
Hopetown.	Long, slightly tapering.	Smooth.	Long, stiff, white.	Bright, plump, transparent.	
Hunter's.	Tapering to neck and point.	Smooth.	Medium.	Brownish, large, elongated, heavy.	For medium and inferior soils.
Morton's red strawed white.	Square, long, close.	Red.	Strong, reedy, red.	White, round, plump.	
Mongoswells.	See Hunter's.				
Malaga.	Compressed, tapering, florets wide apart.		Long.		
Oxford prize.	See Chiddam, which it closely resembles.				
Pearl.	Very square.		Long, stout, white.	Heavy, firm, plump.	For rich soils.
Red chaff white.	Square.	Reddish, smooth.	Short.	Fine.	For rich soils.
Salmon coloured.	Tapering, compressed.	Smooth.	Long.		
Suffolk white.		Smooth.	Long.		
Talavera.	Long, florets far apart.	Smooth.	Long.	Long, coarse, translucent.	For good land.
Trump.	Square, compact.		Short.	Fine.	
Velvet, or Woolly-eared.	Small, close, compact.	Rough.	Short.	Translucent, whitish or brownish.	For rich loams.

II.—WHITE BEARDED VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Californian white.	Close, compact.		Short.	Fine.	
Sherriff's.	Square.	Smooth.	Medium.	Red.	

III.—RED BEARDLESS VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Australian.	Cylindrical, tapering.	Smooth, yellow.	Fine.	Red.	
Browick.	Square, bold.	Smooth.	Strong, medium.	Strong, good.	For medium and poor soils.
Burwell.	Compressed, tapering.	Smooth.	Longer.	Red.	For medium soils.
Creeping red.	Tapering, narrow, cylindrical.	Smooth.	Long.	Small, fine.	For poor soils.
Golden drop.		Red, smooth.		High in the back.	
Lammas.	Cylindrical, tapering.	Smooth.	Medium.	Long, fine.	For good land.
Monmouth.	Square, bold, slightly tapering.	Smooth.	Medium.		
Piper's thick set.	Very compact.	Smooth.	Short, stiff.	Tapering.	For good land.
Dark yellow.	Narrow, tapering, cylindrical.	Smooth.		Long, narrow.	
Spalding.	Square, flattened, slightly tapering.	Smooth.	Strong.	Yellow, large, coarse.	Clays, and soft peat soils.
Tibbalds.	Square, tapering.	Smooth, dark red.			
Kessingland.	Cylindrical, tapering.	Smooth.	Medium.	Coarse, red.	
Nursery.	Cylindrical tapering.	Smooth, whitish.	Medium, fine.	Small, fine.	Good spring wheat.

RED BEARDED VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Californian yellow.	Long, narrow, tapering.	Whitish, smooth.	Fine, short.	Red.	
Cape bearded.	Narrow, cylindrical, tapering.		Long, fine.	Translucent brown.	
Sherriff's.	Compact, square.	Red, smooth.	Medium.	Red.	
April.	Pointed, spreading.		Tall rye-like straw.	Longish.	For late sowing.
Mummy.	Branched.			Coarse.	
Rivett's cone.	Short, compact.	Rough, red.	Solid.	Coarse.	For poor clay, yields largely.

In treating of wheat cultivation we shall consider—(1) the place which the plant occupies in rotations; (2) the soils most suitable for its development; (3) the preparation of the ground; (4) the season of sowing; (5) the quantity of seed used per acre; (6) the methods of sowing; (7) the after cultivation; (8) the harvest; and (9) the cost and return.

PLACE IN ROTATION.

This is usually fixed for tenants by definite clauses, stipulating that no two white crops shall occupy the same ground consecutively; or, still more minutely, the exact position of the various crops towards each other in prescribed rotation. Such restrictions and prescriptions have a certain value on ill-farmed estates, where bad land and poor, uneducated tenants are united under a needy landlord; but they will disappear precisely as good farming extends, and intelligent, well-to-do-tenants increase in number. In ordinary good farming, wheat will follow a bare fallow on stiff soils, or a portion of the root and green fallow. Thus vetches may be consumed on the land as a preparation for wheat, and mangel-wurzel, potatoes, and turnips, consumed early in the season, will leave the land at liberty for winter or spring sowing. Land which has borne a root-crop will, as a rule, be planted with corn of some kind, and the amount set aside for wheat will vary with the season and the natural quality of the soil. Thus clay soil cleared of its root-crop will be suitable for wheat, while light soils, especially when the root-crop is uneaten until late in the season, will be best sown with barley. Over the greater part of the south, west, and east of England, wheat follows one or two years' grass; while in the north, and in Scotland, oats are often taken at this period of the course, while a large breadth of wheat is planted after roots and fallow. Beans also form an excellent preparation for wheat, and cases are not wanting in which strong soils have been cropped for many years alternately with wheat and beans. Wheat has also been grown many years in succession upon the same land, and there is reason for believing that upon some clay soils such a system, aided by steam cultivation and liberal manuring, might be pursued with success.

WHEAT SOILS.

Reference to the above list of varieties will show that there are wheats adapted to almost every kind of land, from peaty, black, soft soils, to hard, poor clays. The stiffer classes of soils have received the general appellation of "wheat lands," because they grow this crop with marked success, and also because they are not adapted for barley and turnip cultivation. Folding sheep upon turnips will give a consistency to even the lightest soils, enabling them to grow wheat and other corn crops successfully.

PREPARATION OF THE GROUND.

Wheat after bare fallow should be sown early in September. This order of cropping presupposes stiff clay soil, and on such soils the earlier the seed is planted the better.

Wheat after roots receives the benefit of all the cultivation bestowed upon the roots. When these are carted off, or fed on the land, plough three to four inches deep, harrow, and drill. A fresh furrow is preferred.

Wheat after Clover.—Eat the pastures bare by means of ewes or other store stock, and plough early, so as to ensure a stale or old furrow. In some cases ploughing is done at the beginning of August, or even earlier; and as a general rule, you can hardly begin too soon. Crosskill or Cambridge roll immediately, to kill the grass and render the ground firm. Harrow repeatedly before and after the drill.

Wheat after Beans.—Cart twelve to fifteen loads of dung on to the bean stubble, plough, and harrow, previous to sowing.

Wheat after Potatoes.—Plough or lightly cultivated, harrow and sow. Land is often too light or hollow after potatoes for wheat; hence deep ploughing is to be avoided.

We cannot recommend indiscriminate deep tillage for wheat. However advisable such a method of cultivation is for stiff soils, over large tracts of light and medium soils it is best to stir the ground deeply for root-crops and plough lightly for cereals.

THE SEASON OF SOWING.

In fallow land, wheat should be sown before the end of September. Root land may be prepared for winter, and spring wheat from October to March, and even up to April. Lea or clover land is best planted with wheat in October and November. Bean land should be sown with winter wheat as early as convenient in the autumn.

THE QUANTITY OF SEED.

Probably no point of farming practice has been more keenly discussed than this. Some of our teachers insist on two pecks per acre of seed as the proper quantity, while others recommend eight pecks. The "thin sowers" have certainly succeeded in reducing the amount of seed used in ordinary practice, just as enthusiastic teetotalers have had their effect on public opinion in the matter of alcoholic drinks, but it is scarcely likely that the amount of seed will be further materially reduced. When we have good land, seeded early in the autumn, the minimum quantity of seed may be used. Experiments have frequently yielded results opposed to thin seeding. Mr. P. Sherriff, who is one of our best authorities on wheat, says: "Respecting the quantity of seed, I can testify from experience and observation . . . that a 'thin plant' . . generally enlarges the ears and corns, retards ripening, and aggravates the effects of red gum and mildew, while the straw is shortened both by a very 'thick' and a very 'thin' plant."* Mr. Blyth, of Sussex Farm, Burnham, Norfolk, during 1839, 1842, 1843, obtained uniformly better results with seven-inch drills and ten and a half pecks per acre, than with nine-inch drills and eight pecks per acre.† T. W. Brampston, Esq., M.P., in 1838 found narrower drilling and a larger amount of seed better than wide drilling and less seed.‡ Mr. W. Loft found eight pecks per acre gave a better crop than five pecks per acre.§ Mr. R. Birch Wolfe, after trying both systems, says the balance is in "favour of narrow drills, seven inches, and the larger amount of seed by seven bushels and seven quarts per acre." ‖ Also Mr. J. F. Burke writes: "I have tried many experiments on sowing wheat on a large farm in the north of Germany, and always found thick sowing was best on the light porous soils, but on clays thin sowing was better."¶

The Cirencester Chamber of Agriculture came to a similar conclusion after a series of experiments carried out by its members in 1869, and we may consider that any attempt to introduce a general system of thin sowing—*i.e.*, less than six to eight pecks per acre—will be attended with loss. Nevertheless, the results obtained by Mr. Mechi, Mr. Wilkins, and the late Mr. Hewit Davis are remarkable, and show the necessity of each farmer testing the requirements of his own land as to quantity of seed.

METHODS OF SOWING.

Drilling, by means of the Suffolk or other corn drills, is the most usual method of planting wheat. It has so completely superseded broadcast sowing in most districts that it is frequently difficult to find a man who thoroughly understands the use of the "seed-lip."

Broadcasting has many points to recommend it. It is a rapid and cheap method of sowing: the treading of horses may be thus avoided, although on much of our lighter soils this is a questionable advantage: the seed is more uniformly distributed than in drilling in rows; the crop is equally successful. When combined with "ribbing," or the formation of small

* Vol. II., *Royal Agricultural Society's Journal*, page 344.
† Vol. V. *ibid.*, p. 352. ‡ Vol. I. *ibid.*, p. 294. § Vol. IX. *ibid.*, p. 281.
‖ Vol. IX. *ibid.*, p. 453. ¶ Vol. IX. *ibid.*, p. 454.

ridgelets, hoeing between the rows may be resorted to. On the other hand, the *drill* has superseded the older system on account of its precision in width, depth, and quantity of seed sown, and the facilities it offers for hoeing.

Dibbling, or depositing one or more grains in holes at a fixed distance apart, is recommended by the advocates of thin sowing as economical of seed. For early autumn sowing on good land it may answer, but it is a risky method of sowing.

Ploughing in is sometimes adopted with good effect. The wheat is sowed broadcast on the surface, and covered with a light furrow. This secures a firm bed for the wheat, a condition generally favourable to the development of the crop.

PREPARATION OF THE SEED.

Wheat is "pickled" or "steeped" before sowing. This is best done with sulphate of copper or blue vitriol, 1 lb. of which is dissolved in 2 gallons of water for every quarter of wheat. A sufficient quantity of the solution having been made, the seed is lowered into it in a basket for a few seconds. The light grains which rise to the top are skimmed off, and the basket is withdrawn and allowed to drain. The wheat is then thrown on to a floor, and turned over with a shovel until it is dry. This process is used in order to destroy the germs of fungi in contact with the seed, which if unchecked would subsequently develop into "bunt" or "smut."

THE AFTER CULTIVATION.

consists in spring rolling, and, when the land is foul, in horse and hand hoeing. On stiff soils wheat is often benefited in the spring by harrowing, especially if, owing to rapid alternation from wet to dry weather, the soil has become set into a crust or scrap on the surface around the young plants. These tillage operations should only be attempted when the ground is dry. If the plant is thin and weak, 1½ cwt. of nitrate of soda or sulphate of ammonia may be applied with good effect in showery weather in April. Should the plant be too luxuriant, it may be checked by eating it down bare with sheep. This should not be attempted after mid-April. Flagging consists in removing the heavy foliage by means of hooks or scythes when it is seen to be likely to cause the crop to "lodge" or fall. This is done in May, and is so conducted as not to injure the young ear, whose position in the straw should be ascertained in order to guide the operator. Common salt is sometimes used as a top-dressing for checking the over-luxuriance of straw, and may be applied in April or May at the rate of 2 to 3 cwt. per acre.

HARVESTING.

The bloom or flower appears upon the young ear six weeks before harvest. This flowering period is considered critical, and requires quiet, genial weather. Sudden changes of temperature or high winds do incalculable injury. The proper period for cutting is indicated by the characteristic colour of the straw and the condition of the grain.

The old-fashioned practice was not to cut until the corn was dead ripe—"goose-necked," as it was called, on account of the bent appearance of the head and upper portion of the straw. It has, however, been demonstrated that there are serious disadvantages in thus delaying harvest operations. Not only is an important work postponed to a season when the weather is less certain, but we run the risk of loss from winds blowing out the grain. The straw also becomes harder and less useful as fodder for stock, while the skin of the grain thickens so that less flour and more bran is yielded. The best period for cutting is when the grain, although soft enough to yield to the pressure of the thumb and finger, does not when squeezed exude a milky juice, but a pasty, semi-solid mass.

Machines are now in general use for cutting corn of all kinds. We cannot pause to inquire into the history of the reaping-machine, or even to compare the relative merits of the many forms before the public. The advantages of this mode of cutting are, however, sufficiently evident, and may be summed up as follows:—A cheaper and quicker method than either sickle or scythe; the employment of horses at a time when they were formerly idle; diminished risks, especially from wind. Side delivery machines, which leave the corn in bundles ready for tying up, such as are sent out by Hornsby of Grantham, or Samuelson of Banbury, are the best for wheat; while a machine like Burgess and Key's, which leaves a continuous swathe, is most suitable for barley.

If the weather is unsettled, the wheat should be at once tied up and stacked; but in fine weather it will be all the better for lying a few hours in "broad-band." Sheaves should be of good form, with all the heads at one end, square at the butt, and tied tightly, rather nearer the butts than the heads. Stooks should be composed of six pairs of sheaves each, firmly set down, pointing south-west and north-east, and the stook rows should be straight. The time required for drying the corn is variable. Sometimes it may be cut and carted at once, while at other times a fortnight will elapse before it is "fit." Wheat is fit to cart when the straw is dry at the nodes or knots, and when the grain is hard. If it is required for marketing at once, it must be dry enough for grinding; but if it is intended to stand in the stack-yard over winter, it need not be in such good "condition." In carting we may either stack in the field or carry to the rick-yard. In either case we shall require one man pitching in the field, one man pitching at the stack, one boy loading carts in the field, one man making the rick, one woman raking in the field, one to three people assisting on the stack, and carts according to distance. The cost of harvesting may be thus estimated:—

	s.	d.
Cutting by machinery	1	6
Taking up, tying, and stooking	4	6
Pitching and loading	1	0
Rick-building	0	8
Carrying	0	8
Thatching	1	4
Total per acre	9	8

Harvesting requires close attention from the master, who will find his judgment continually exercised in watching the weather, determining when to cut or cart, and superintending the work-people. We conclude this brief account of wheat cultivation with an estimate of the cost of growing a crop of wheat after lea, and of the probable return:—

		s.	d.
Ploughing		8	0
Crosskill rolling		1	3
Harrowing before and after drill		2	0
Drilling		1	10
Seed, 2 bushels per acre, at 6s.		12	0
Rolling in the spring		0	9
Hoeing		3	6
Harvesting		9	8
Threshing		6	0
Marketing		5	0
	£2	10	0
Rent, taxes, etc.	1	15	0
	£4	5	0

The probable yield may be taken at 30 bushels, and the price at 6s. per bushel. This will give a return of £9 per acre, and apparently a handsome profit. In order to arrive at a true idea of profit, it will be necessary to take the whole rotation into account, as some crops, such as the one under consideration, although profitable, are preceded and followed by unremunerative or possibly losing crops.

NOTABLE INVENTORS AND INVENTIONS.

XXIV.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS" (*concluded*).

BY JOHN TIMBS.

52. *A mystical jingling of church bells*, by which, varying the order of arrangement, the whole alphabet may be rung on three bells; and these, being formed into sentences by short pauses between each word, will fully serve for distant conversation. For musical instruments, it is merely changing keys for bells.

53. *A hollowing of a water-screw;* a leathern water-pipe, nailed in a spiral form round a long circular pole, the most simple method of making the Archimedean screw.

54. *How to make a water-tight screw;* by making a coarse screw and covering it with horn, or fitting a spiral tube of glass on a wooden cylinder, and filling up the interstices with wax or any hard cement, so as to project beyond the glass tube.

55. *A double water-screw*, the innermost to mount the water, and the outermost for it to descend more in number of threads, and consequently in number of waters, though much shorter

than the innermost screw, by which the water ascendeth, a most extraordinary help for the turning of the screw to make the water rise. How a larger quantity of water can descend than has previously risen it is hard to say.

56. *An advantageous change of centres;* all the weights of the descending side of a wheel being perpetually further from the centre than those of the mounting side, and yet equal in number and heft of the one side as the other: tried before the King and court by the Marquis's directions, in the Tower. The experiment was made more than fifty years prior to that of Orffyreus, a German mechanic, whence he is presumed to have derived the idea from the Marquis's work.

57. *A constant water flowing and ebbing motion,* upon the principle of an ebbing and flowing spring. The throwing in of a ball, by causing a commensurate rise of the water, fills a syphon, and sets the water-work in motion; but as the effect of this would soon cease after the two vessels attained an equilibrium, the machine must be assisted by a moving power attached to one or both of the vessels, as the Marquis merely says that it may be performed "without the help of any man *within sight or hearing.*"

58 to 67. *Improvements of considerable importance in the principle of modern fire-arms.* One invention, the effect of electricity applied to gun batteries.

68. A fire water-work, already described.

69. A triangle key.

70. A rose key.

71. A square key, with a turning screw.

72. An escutcheon for all locks.

73. *A transmittible gallery* over any ditch or breach in a town wall, with a blind and parapet, cannon-proof.

74. *A conceited door,* whereof the turning of a key, with the help and motion of the handle, makes the hinges to be of either side, and to open either inward or outward, to enter or to go out, or to open in half. By making the handle act on a lever communicating with the hinges, they may be raised from their sockets on the required side, and to open in half they are jointed in the centre.

75. How a tape or ribbon weaver may set down a whole discourse without knowing a letter. (See 33, 34, and 35.) It may be performed either by making the stitches of a given length, varying the distance; or by any shape agreed upon by the parties, when the silk weaver will have only to set his loom to the required pattern.

76. *How to write in the dark,* as straight as by day or candle light. "Two planes of ebony of equal length and breadth, similar to the parallel ruler, joined at each end by racks, the side of which being graduated to the width of the line intended, will serve as a certain guide; and by the use of this instrument a blind person may write with the greatest accuracy. If ivory tablets or a slate is used, a fine wire drawn with a steel point may be readily felt by the point of the pencil."—*Partington,* note.

77. *How to make a man to fly;* which the Marquis tried with a little boy of ten years old, in a barn, from one end to the other, on a hay-mow. Upon this Mr. Partington has a note of six closely-printed pages, from which we can only quote that the whole problem of aërial navigation is confined within these limits, viz.: "To make a surface support a given weight by the application of power to the resistance of the surrounding atmosphere." The subject is, however, far beyond our limit.

78. *A watch to go constantly,* yet needing no other winding from the first setting. It will be necessary to employ a small balance, with a nut attached to its axis, and communicating with the fusee, the continued vibration of which will, by winding the watch, give it nearly all the advantages of a perpetual prime mover.

79. *A way to lock all the boxes of a cabinet at one time;* to be performed either by cranks and wires, or by sliding bolts and levers communicating with each lock. A more simple mode is the use of a series of spring locks, which may be closed by the pressure of the lid, unconnected with any other mechanism.

80. *How to make a pistol-barrel no thicker than a shilling,* yet able to endure a musket-proof of powder and bullet.

81. *A comb conveyance* for carrying letters without suspicion, the head being opened with a needle screw drawing a spring towards one.

82. *A knife, spoon, or fork,* in a portable case, may have the like conveyances in their handles.

83. *A rasping mill for hartshorn,* for which a variety of engines have been invented.

84. *An arithmetical instrument,* whereby persons ignorant of arithmetic may perfectly observe numeration and subtraction of all sums and fractions. The unfinished calculating instrument of the late Charles Babbage is, however, much superior to any other contrivance yet suggested, unless it be Scheutz's difference engine.

85. *An untoothsome pear,* which being dexterously conveyed or forced into a body's mouth, shall shoot forth so many steel bolts at each side, and at both ends; can neither be opened nor filed off. This discovery may be set down as useless.

86. *An imprisoning chair,* in which a stranger seating himself, has immediately his arms and thighs locked up, beyond his own power to loosen them. "Chairs of this description," says Partington, "were employed by the monks in the darker ages of Christianity, to entrap curious persons; they were provided with two levers at the extremity of the arms, and the same number were fixed immediately below the seat. These, on pressing the cushion, were discharged like a man-trap, by four powerful springs acting on the lever, so that it would take the united force of four or five persons to free the prisoner."

87. *A brass mould to cast candles,* in which a man may make 500 dozen in a day.

88. An engine, without the least noise, knock, or use of fire, to coin and stamp 100 lbs. in an hour by one man. The Marquis was ignorant of Boucher's fly-press for multiplying metallic impressions from an engraved surface.

88*a*. *A brazen head* that answereth a whisper into his ear, in French, Latin, Welsh, Irish, or English, uttering it out of his mouth, and then shut it. But this invention has been transcended by the Invisible Girl of our day. Partington's descriptive note is very interesting. but too long for quotation.

89. *White silk gloves,* knotted in the fingers, with which a card-player may, by the knots or rings, keep reckoning of all sixes, sevens, and aces, which he hath discarded, and without false play.

90. *A dicing box,* with holes transparent, and by a knock of it against the table the four good dice are flattened, and it looseneth false dice made fit for this purpose.

91. *An artificial horse,* on which a man being mounted, he can make him start, and run at the ring—an automaton figure.

92. *A gravel engine,* made like a water-screw.

93. *The water canal.* An engine whereby one man may take out of the water a ship of 500 tons, so that it may be caulked, trimmed, and repaired, without need of the stocks, and as easily let down again.

94. *A little portable engine,* called a jack, for opening a door or gate; its even, uniform motion is clearly described by the Marquis of Worcester.

95. *A double cross-bow,* to shoot two arrows in immediate succession.

96. *A way to make a sea-bank,* described precisely by the noble inventor, in its results, like the Breakwater at Plymouth.

97. *A perspective instrument,* answering the description of the camera obscura and camera lucida.

98. *The semi-omnipotent engine,* so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, straight, upright or downright, yet the pretended operation continueth and advanceth, none of the motions above mentioned hindering, much less stopping, the other, etc. etc. (See page 43.)

99. *A most admirable way to raise weight.* How to make one pound weight to raise one hundred as high as one pound falleth, and yet the hundred pounds descending doth what nothing less than one hundred pounds could effect.

100. This, "the most stupendous work" of the whole "Century," has already been noticed (page 43). Whatever may be the worth of the majority of the "Century of Inventions,"* it is now a generally accepted fact that the Marquis had worked out in his mind a clear conception of a steam-engine, as we should now call it; and he is believed, shortly before his death, to have set at work a model of a steam-engine, from which, it is believed, Savery took his hints of the engine, which, since Watt's improvements, has remained "the only tame giant that is usefully subject to the will of man."—*Hawkshaw.*

* Since the publication of Partington's edition has appeared the exhaustive "Biography of the Marquis of Worcester," by Mr. Dircks, C.E.

TECHNICAL DRAWING.—LIV.

GOTHIC STONEWORK.

EARLY ENGLISH WINDOWS (*continued*).

THE separate lights of these windows are generally placed at some distance apart on the exterior, so as scarcely to appear as if belonging to the same window; but in the interior, owing to the great splay given to each light, the distance between them appears inconsiderable, giving them the appearance of a single compound window.

In windows of three lights, such as that from Stanton Harcourt, Oxfordshire, shown in Fig. 476, the centre one is almost always the highest, its head rising considerably above the others, so as to preserve the arched appearance of the whole. Windows of four lights, with centre pair rising above the outer ones, are occasionally met with, but the most general by far are those of three, five, or seven lights, rising in height to the centre one. These lights were sometimes gathered under a single arched dripstone, as in the west window of the south aisle of Oundle Church, Northamptonshire, and covered by a dripstone, which, like the string-course already alluded to, covers first one light, is carried on horizontally, rises to the level of the springing of the next, follows the arch, descends to the level of the next springing, and so on, producing a very graceful effect. The window shown in this illustration is an excellent example of this kind of dripstone.

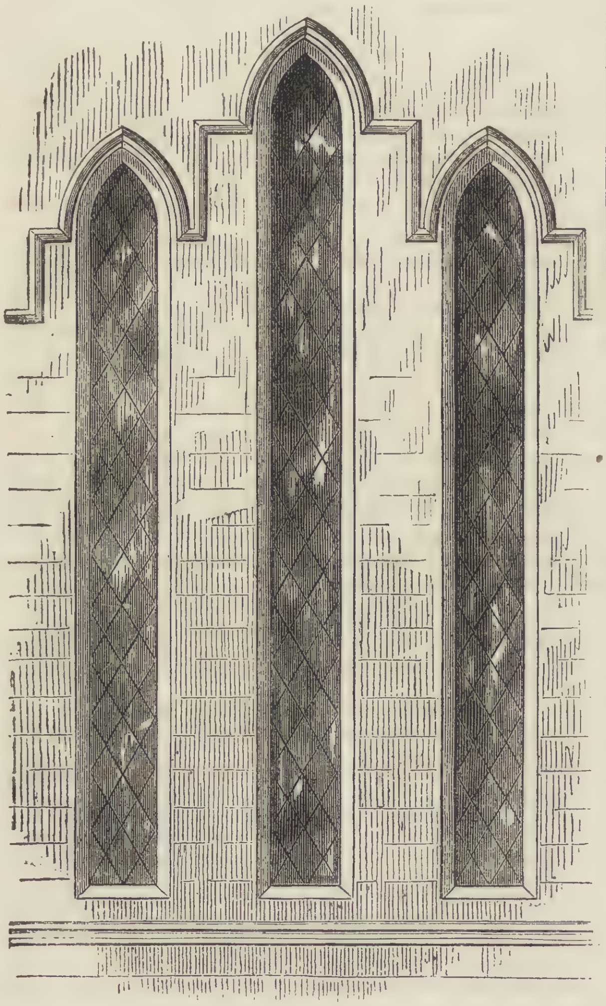


Fig. 476.—THREE-LIGHT WINDOW FROM STANTON HARCOURT, OXFORDSHIRE.

It has been shown in the previous lesson that when two lights were gathered under one dripstone, a blank space, known as the "tympanum," was left. But in process of time this space began to be pierced with another small light in the form of an ellipse, a circle, or trefoil, which at once relieved the blank space beneath the arch, and admitted more light. In Fig. 477 is given a window from Little Wenham Church, Suffolk, in which the space between the heads of the two lights is pierced by a diamond-like aperture, the two lower sides of which correspond with the inner sides of the arches, and the two upper sides being merely continuations of the outer sides, the same centres being used.

Fig. 477.—TWO-LIGHT WINDOW FROM LITTLE WENHAM CHURCH, SUFFOLK.

At Brownsover Church, Warwickshire, the upper corners of this aperture correspond with that of the outer arch or dripstone; but as this is not, as in the present instance, struck from the same centre as the heads of the lights, the effect is not so pleasant, presenting a broken, instead of a continuous curve, as shown in our illustration.

This elementary stage of ornamentation is called "*plate-tracery.*"

A two-light window, with a lozenge form or quatrefoiled circle between the heads, was, as we have seen, the first decided step toward tracery. "It was," says Mr. Brandon, "a natural and easy advance to place two such windows in combination, and to pierce with a larger circle the space enclosed by a dripstone, forming a single arch above them both. Here

appears, therefore, a four-light window with its geometrical tracery. Then one of the lights would, no less naturally, in some instances be suppressed; while, under circumstances of a contrary nature, a fifth or even a sixth light might be introduced, and in each of these cases alteration in the tracery must necessarily ensue. And, again, every such alteration would

In early cusped circles there is a distinctive peculiarity in the cusping. In these the foils are produced from the inner curve without rising at all into the chamfer. This style has been called *soffit* cusping, because it rises directly from the soffit of the arch, and not, as subsequently, from the chamfer or slope of the arch-side.

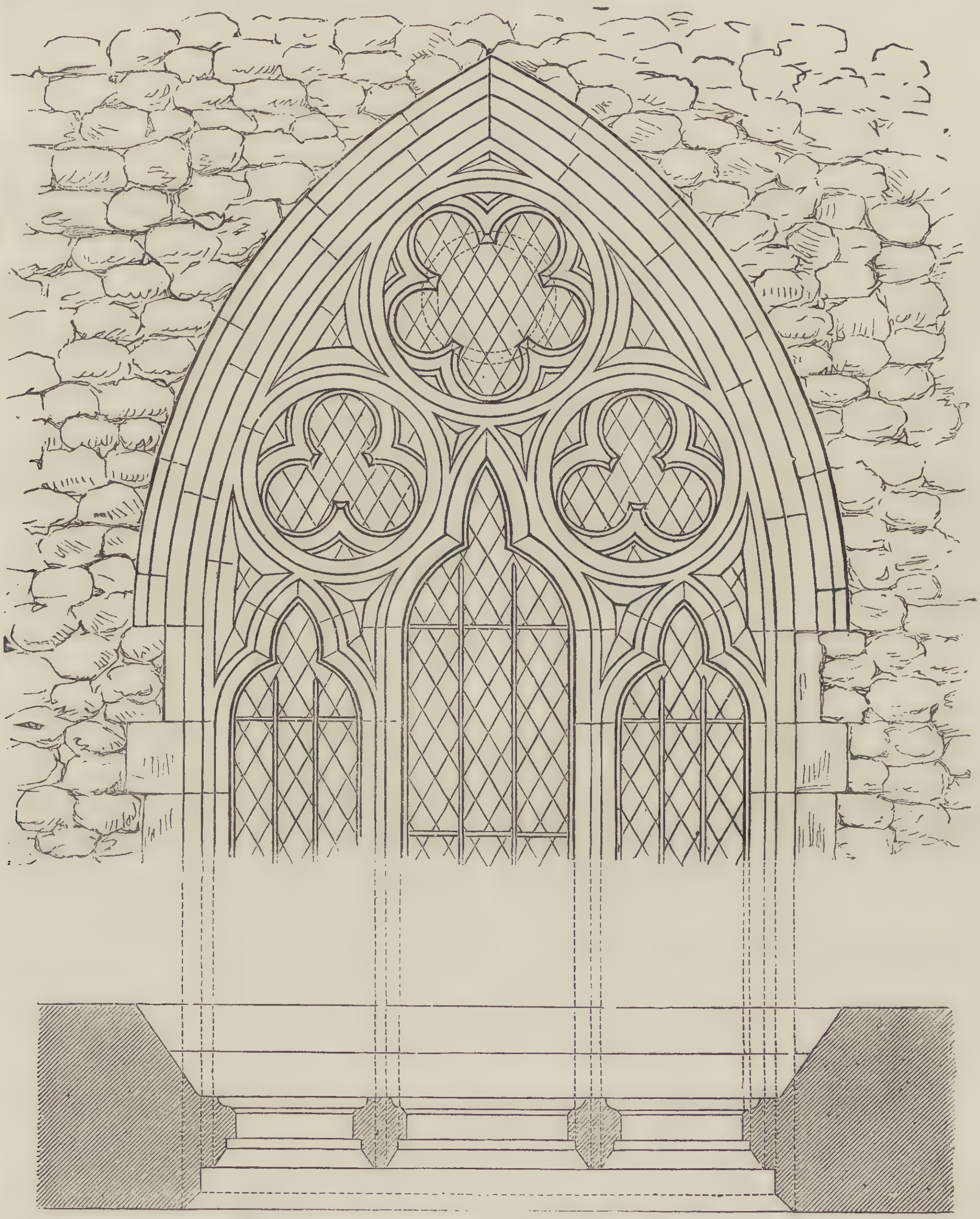


Fig. 478.—WINDOW FROM MEOPHAM CHURCH, KENT.

lead to the introduction of fresh variety, and thus illustrate the facility with which window tracery admits of change, even whilst fettered by geometric forms of beauty or consistency. In the first instance, in these early windows the cusping was for the most part restricted to the geometrical tracery, the heads of the lights remaining plain; but after a while a similar enrichment was introduced into the heads of the lights, to the great improvement of the entire composition."

Another marked peculiarity in early foils is, that in place of being segments of intersecting circles, they are formed from a series of distinct circles which all cut a larger circle within. Tracery in the cusping of which any of these peculiarities occur, is invariably of an Early English when not actually of a Transitional character. The window from Meopham Church, Kent (Fig. 478), illustrates this early cusping.

It has been shown that the first advance towards the develop-

ment of tracery was caused by the tympanum being pierced with an aperture in the form of a circle, trefoil, lozenge, etc., and that to this the name of plate-tracery had been applied. The system shown in the present example is characterised by the name "bar-tracery" in contradistinction to plate-tracery, illustrated in the previous figure, the patterns of the openings appearing to be formed by the intersection of various bars. This latter form arose naturally enough from the former by the multiplication of the piercings or apertures, till at last the plate disappeared, excepting such parts as were required to separate the openings and to connect the various parts.

In copying this example the student is advised to draw the plan first—not necessarily to the same scale; in fact, it would afford better practice to work to a larger scale, say 1 inch to the foot. The plan having been completed, the external form of the elevation and the mullions should be projected from it. The mullions develop into the tracery bars. The narrow, flat edges of the tracery—*i.e.*, those parts which form the plane of the whole front of the window—should next be drawn. The rest of the construction will be easily followed from the illustration.

Circular or rose-windows (called also wheel-windows and marigold-windows) are not unfrequent at this period, and are divided into compartments by slender shafts with capitals radiating from the centre, and sustaining at the circumference small arches usually trefoiled. Windows of triangular shape are also found, as well as a peculiar sort of window in the form of what is called the "vesica piscis;"* these are small, and are placed in subordinate positions, as in the gables or clerestories of parish churches. Beverley Minster, York, and Lincoln have circular windows of this style, peculiarly fine in character. The marigold-window in the south transept at York is also extremely rich; and there are the remains of a beautiful window of this kind in the front of the ruin of Valle Crucis Abbey, Llangollen, North Wales, already referred to.

* *Vesica piscis.*—A figure frequently used in Early English and Gothic architecture. Generally the form is something like an ellipse, but pointed at both ends. It is formed by the intersection of two arcs of equal circles, and is somewhat similar in outline to a fish—hence its name. This form is sometimes given to the *aureole*, or nimbus of glory, in which representations of saints are enclosed.

CHEMISTRY APPLIED TO THE ARTS.—XIV.

BY GEORGE GLADSTONE, F.C.S.

GLASS-MAKING (*continued*).

In the last article we considered the manufacture of glass vessels, from the commonest bottles up to the ornamental cut ware. We have now to deal with the various kinds of glass which are used in the form of flat sheets. These are divisible into three principal classes—crown, sheet, and plate glass. They will be taken in order.

Crown glass was almost exclusively manufactured in this country until a comparatively recent period. It generally consists of silica, soda, and lime; with a little binoxide of manganese and arsenic to neutralise the effect of any oxide of iron or other impurities that may be present in the materials employed. The proportion of the several ingredients varies considerably in different works, and even at different times in the same works; but the following may be taken as about an average:—Sand, 500 lbs.; chalk, 150 lbs.; carbonate and sulphate of soda, 175 lbs.; cullet, 450 lbs. Sulphate of soda has the advantage over the carbonate of being cheaper and more easily worked, but it does not yield so colourless a glass; and therefore the use of the one or the other, or the relative proportions of the two, are governed by the quality of glass that may be desired.

The materials are mixed together and put into a pot similar to that described in the last article as used in making bottle-glass, except that a ring of clay is first put at the bottom of the pot. During the melting this rises to the surface, having a lighter specific gravity than the metal, and its presence there serves to reduce the space which it is necessary to keep clear of impurities during the manufacturing process. The pipe and the punty, as before, are the principal tools used. The workman gathers upon the end of his pipe, in successive dips, about 9 lbs. weight of metal, which he rolls upon his table or "marver" until it assumes a conical form, the apex of the cone being the bullion point. While continuing to roll it on the marver, a boy blows down the pipe, and it is heated and blown alternately until it attains the size of a glass globe. It is again heated at the furnace-hole and rotated rapidly, which causes the globe to flatten at what a geographer would call the poles, and widen out greatly at the equator. The next workman then takes it upon the punty, on the knob of which is a little hot metal fresh from the pot, which he applies to the bullion point; it adheres immediately, and then the pipe is cut off on the opposite side with a piece of cold iron, leaving, of course, a small hole where the nose of the pipe was. It is taken without a moment's delay to the flashing furnace, which is kept up at a great heat; and in front of this intense fire it is rapidly rotated until the side in which is the nose-hole gradually melts and extends, until at length it can no longer resist the centrifugal force, and bursts open, forming a flat circular disk of glass about 60 inches in diameter. Still twirling the punty, the glass is removed from the fire, and as soon as it is cool enough to retain its shape it is detached from the iron rod and taken to the annealing oven, where it remains one or two days.

A well-manufactured table should be very even in thickness, except, of course, in the centre, which is the bullion point or bull's-eye. There are generally, however, some slight indications of the way in which it is made, as window-panes will often be seen to contain striæ or markings which form segments of circles having a common centre; these are objectionable, as they slightly distort the objects seen through them. It is liable, like other glass, to accidental impurities in the metal, and also to the presence of bubbles, the latter generally arising from insufficient melting. In crown glass the bubbles are, moreover, more conspicuous than in plate, as they are drawn out and flattened by the rotatory action, till they present ultimately the appearance of large flattened disks. All these defects more or less detract from the value of the glass, the best being about three times the value of the commonest; and in cutting it for the market considerable judgment has to be exercised by the cutter, so as to secure wherever possible a piece that shall rank among the upper qualities. The table is only cut into two portions: the one which contains the bull's-eye being, of course, larger than the other.

Sheet glass works have only been established, or rather re-established, in this country within the last forty years; and in them the same materials are employed as those just described for making crown glass. The difference consists in the mode of manipulation. It will be sufficiently evident that a circular plate of glass of 60, or at the most 70, inches in diameter, and which has a bull's-eye in the centre, cannot possibly be cut so as to yield a large square; and that it will not, therefore, suit modern ideas of glazing windows, and still less of shop-fronts. The making of sheet glass, which had for a long time been superseded by the crown (partly, perhaps, because of the more brilliant surface of the latter), has now, therefore, been revived.

The workman takes a lump of metal upon the end of his pipe, as in the former process, and blows it upon a hollowed block of wood instead of a table, so as to limit the hollow ball to a certain diameter. The wood is preserved from being burnt by pouring water upon it, and the metal being at that time sufficiently hot to convert the water into steam immediately, the glass is not rendered brittle by its presence. In front of each working-hole of the furnace is a wooden platform, with a pit below, and upon this platform the blower now stands, and, by a succession of re-heatings, blowings, and swings round of the metal in a vertical plane, the hollow ball gradually becomes drawn out into a long cylinder. The extreme end of it opposite to the pipe will naturally be thinner than the rest; this part is then made very hot, and is burst open by the expansion of the internal air through the heat, the end of the pipe being closed to prevent its escape in that direction. The edge of the orifice thus caused is trimmed with the scissors, and the aperture widened with the tongs until the cylinder is of uniform diameter throughout. It is then cut off at the other end, by passing a hot iron round it, and dropping some cold water on the heated line. It thus forms a long glass drum, open at both ends.

This drum has now to be split and flattened. The first is partially done by taking a diamond, and drawing a straight line longitudinally along the inner surface of the glass. In this condition it passes to the flattener. By him it is laid upon a

smooth plate, with the cracked side uppermost, and heated at the flattening furnace, when it opens along the line where the diamond has passed, and gradually sinks down upon the plate as a flat sheet of glass. The flattening is, however, expedited by passing an iron ruler over it as soon as it has commenced to gape open; and when quite flat a rod with a smooth block of wood at the end of it is employed wherewith to rub the surface so as to take out any roughness or waviness which may remain. It then only requires annealing, and the sheet is finished.

Glass thus made is free from some of the defects incident to the crown process; but in the flattening and rubbing it loses the fine smooth surface which the other has, and though largely used for the glazing of windows, its appearance is not altogether satisfactory. An economical, and at the same time efficient way of grinding and polishing the sheets has, however, been discovered, so that now it may be had with as fine a surface as plate glass, and it is used as a substitute for the latter in the glazing of the best houses. The sheet of glass is pressed upon a damp piece of soft leather stretched on a flat frame, which is all that is requisite to make it adhere firmly. Two of these are then laid face to face, and are rubbed together by machinery, sand and water being made to flow between them. They thus grind and polish each other; and as soon as the one surface is done, they are turned, and the process is repeated.

The usual size of a sheet is 47 inches by 32; but for special purposes larger sizes are sometimes made. Sheets of large dimensions and corresponding thickness are, however, very trying to the strength of the workmen who have to make the cylinders.

The International Exhibition building of 1851 was glazed with the unpolished sheet glass; each cylinder was made to produce a sheet measuring 49 by 30 inches, which was afterwards cut lengthways into three equal parts. Of these about 300,000 were required for the purpose, the whole of which were manufactured by one firm, the Messrs. Chance, of Birmingham.

Plate glass is made by a comparatively simple process; but as the main object of making it is to obtain very large sizes, which must have a corresponding thickness, very great care is necessary at every step, lest when finished it should be found to contain flaws or have too much colour. A plate to be used as a mirror should indeed be absolutely free from any blemish; and if it has a slight greenish tinge, it gives, after being silvered, a very unpleasant tint to the objects reflected by it.

In the first place, the very best materials must be used, and the sand should be well washed to remove any accidental impurities. The following are good proportions:—

Best white sand	42·5	per cent.
Soda salt, 40 per cent. of alkali	26·0	"
Caustic lime	5·0	"
Nitrate of potash	1·5	"
Cullet	25·0	"
	100·0	

These will be seen to differ essentially from flint glass, not only in the absence of lead salts, but also in the use of soda principally instead of potash. This causes all plate glass to be more or less greenish, but at the same time it renders the metal more fluid, which is a matter of some importance in the casting, and it also facilitates the separation of any impurities that there may be in it. By increasing the quantity of potash, a more colourless glass would be obtained; but this alkali has such a faculty of absorbing water that glass made with an excess of it will become sweaty, and cannot be kept clean and bright.

The ingredients are melted in the open-mouthed pots already described, and when ready for use the casting-pot is rapidly withdrawn from the furnace by a travelling crane, and brought over the table. This is a large sheet of iron resting on a frame which runs on wheels; the iron top is highly polished, and has a movable strip of metal on each side, which is varied according to the intended thickness of the glass. Before using it, the surface of the table has to be heated, which is generally done by sprinkling hot coals upon it, after which it is wiped quite clean.

The metal, after having been kept at the fullest heat until all the bubbles have escaped, is allowed to cool down a little till it commences to lose its liquidity, and to become slightly viscid. It is then (after being skimmed) ready for pouring out upon the table. As soon as that is done, a heavy metal roller is passed over it, and the glass is thus rolled out into a flat sheet of the thickness corresponding to that of the side strips above described. Any excess of metal falls over the end of the table which is left unprotected. This, while still soft, is bent upwards in the form of a flange, so as to be free of the table for the next operation.

The whole is then wheeled to the door of the annealing oven, and the sheet of glass is pushed in by pressure on the flange at the farther end; there it remains for some days, during which the temperature is gradually reduced from a dull red heat, at which it was at first, until it becomes cool.

When the annealing is complete the plates have to be carefully examined for flaws, and are cut into the largest squares that can be obtained without including any of these. They then pass to the grinding and polishing house. A large plate is firmly fixed with plaster of Paris on the top of the grinding-bench; a small one is likewise fixed on the under side of a heavy travelling table, to which a rotatory and at the same time oscillating motion is given by the machine with which it is connected. Thus one plate is made to grind the other, with the help of fine sand or ground flint and water, which is thrown between them. Both sides are ground in this way. They have then to undergo a succession of grindings by hand, with emery powder of gradually increasing fineness, so as to reduce the coarseness of the granulation caused by the machine-grinding, and gradually to prepare it to receive a polish. Women and girls generally do this best, as it must be done lightly; and their hands more readily detect any grittiness in the emery powder, which has specially to be guarded against.

The polishing is done with a woollen cushion, and a composition containing a little of the hydrated oxide of iron; the cushion is attached to a handle which is usually driven by machinery, as that does the work more regularly and systematically than hand labour, and produces in consequence a more even result.

When the plates were in their rough state many minor flaws might pass undetected, which unfortunately cannot escape notice when the glass has received its fine polished surface. They must needs, therefore, be re-examined, and the defective portions cut away. The pieces which are most free from colour, waviness, and bubbles, are selected for the making of mirrors; the rest being used for glazing or any other purpose of minor importance.

The very general employment of plate glass in shop-fronts has given a great impetus to the manufacture; but, besides the home consumption, it is exported to other parts of the world in considerable quantity, as there are no plate glass works of importance yet established either in the United States of America or in our own colonies.

THE LATHE.—IV.

By Henry Northcott.

ADVANTAGES OF DOUBLE GEARING FOR LATHES.

The usefulness of the double gearing is considerable, for though simple, it adds a great deal to the power and use of a lathe. It is not always made in the manner shown in our last paper, but this arrangement illustrates the principle of the most approved mode of application. In some cases the wheels, instead of sliding towards and away from each other by diminishing or increasing the distance between the axis, are thrown into gear and out of gear by the back axis sliding lengthwise in its bearings a distance rather in excess of the width of the wheels; but in the best lathes the back shaft is a socket mounted on a central spindle, which latter is carried by two eccentrics, and with this arrangement the wheels are caused to approach and gear with each other or recede by moving round the eccentrics. This latter plan is probably the neatest and most complete, but the second is, I think, the simplest. Both plans are in very frequent use, and will be illustrated in some of the complete lathes to be shortly described.

Although this double gearing allows of a very great reduction of the speed of the lathe-spindle and corresponding increase in its power of overcoming resistance, a still greater reduction of speed and increase of power are required for some large lathes,

and consequently these lathes are sometimes furnished with treble and quadruple gearing of very great complexity and power. In most of these very powerful lathes the last pinion is caused to gear directly with a large wheel forming part of the disc or circular plate on the lathe-spindle nose which carries the work. The object of this is that the great torsional strain which would otherwise be transmitted through the lathe-spindle itself, and which would consequently have to be made very strong to enable it to safely transmit such strain, shall be communicated directly to the face-plate, and applied as near as possible to the spot where the resistance of the tool's cut has to be overcome. Such powerful and complicated trains of wheels are chiefly necessary for lathes that are designed for turning very large surfaces, and which lathes are hence called surfacing lathes.

I am not aware who was the originator of the double gearing, but it is a most valuable invention. In its earlier shape it was applied something in this way:—An ordinary lathe face-plate was furnished with a wheel which was attached to its back, and a small pinion was fastened at the back of the lathe-head by a bracket bolted to the lathe head-stock. This pinion was arranged to gear with the wheel on the face-plate when heavy work had to be turned in the lathe, or it could be removed from gear when the slow motion was not required. The small pinion received its motion not from the lathe-pulley in any way, but from the overhead shaft driven by a separate belt. Now, this arrangement was quite as efficient as any of those since introduced in reducing the speed of the work within the range of a simple wheel and pinion, but the plan necessitated a separate belt, which was rather in the way when the ordinary motion was required. A lathe fitted with this kind of gearing I have seen, but have no idea of its age. When I saw it, it had for some time been consigned to that depository for all useless lumber known in engineering establishments as the "scrap heap." Many rude forms of slow-motion gear have, doubtless, been devised in the early days of the modern lathe, but most of them, probably, have never been known outside the workshop where they were originated; and they may be classed with the numberless little ingenuities and improvements that are continually being called into existence by the cunning brain of the clever mechanic, and which inventions form but a very small part of his weekly labours.

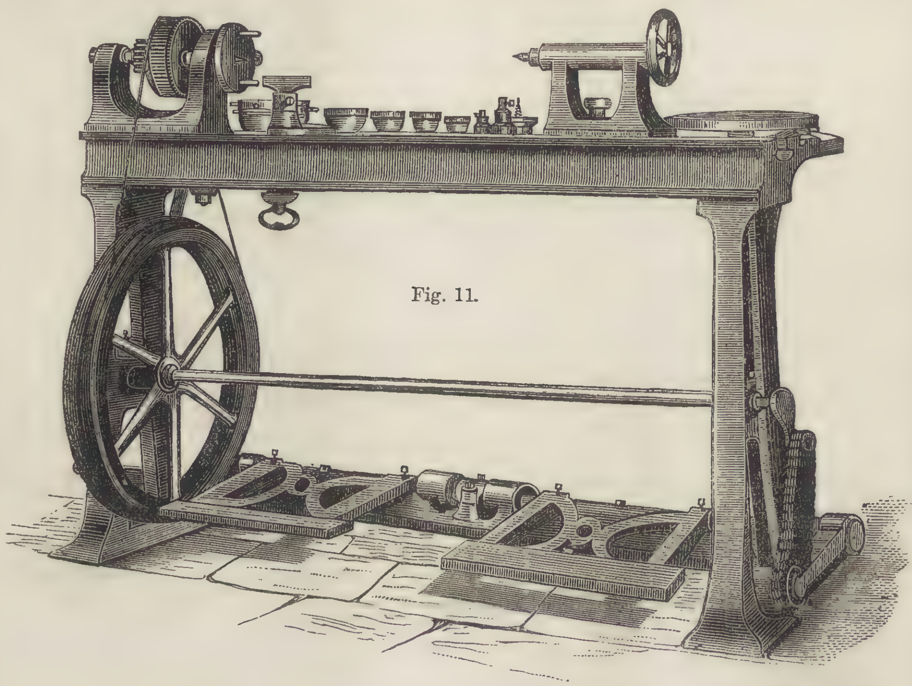


Fig. 11.

The double gear as now employed leaves very little to be desired; it is simple, thoroughly efficient, is easily put into and out of use, and when not wanted, it is not in the way or inconvenient. For small fast-running lathes the wheels should be machine cut, that is, their teeth should be cut out of the solid metal by a wheel-cutting machine, as this causes them to run smoothly and with little noise. It is also a very common practice to make the wheels with oblique teeth instead of the usual square teeth, and no doubt such wheels are well adapted to the purpose, as they gear with each other evenly, and run at a high speed with very little tremor or noise. For large lathes the gear-wheels are ordinary well-moulded spur-wheels, chucked with reference chiefly to the teeth, and turned up true upon the face and sides of the toothed rim. Such wheels are sufficiently accurate for the purpose, and as they do not run at any great speed they do not make much noise in working. The most usual mode of connecting the large wheel on the lathe-spindle with the cone-pulley, is by a sliding screw or bolt passing through the spur-wheel, and having a T-head inside and a washer and nut on the outside of the wheel. The cone-pulley is accurately mounted upon the lathe-spindle, and is cast with a flange on the side abutting against the spur-wheel, and in this flange is cut one or more spaces for receiving the T-head of the sliding bolt. When the spindle has to run at the fast speed the wheel and pulley are connected by sliding the small bolt outwards until the head of the bolt falls into the space cut in the pulley-flange, and in this position the bolt is kept by tightening the nut on its outside extremity. When the spindle is wanted to rotate at a slow speed, and independently of the lathe-pulley, the nut is loosened and the bolt slid outside of the space cut in the flange, when the nut is again tightened. For light fast-running lathes using this mode of connection, it is as well to balance the momentum of the sliding bolt by a counterweight cast on the spur-wheel on the other side of its axis. If this is not done the lathe will shake a great deal at high speed, and cause undue wear of the bearings of the lathe-spindle, as well as danger to slight and accurate work. In some lathes the connection at will between the wheel and pulley is formed by a screw passing through the plate of the wheel, and screwing into the metal of the pulley. This screw is removed altogether when the slow-motion gear is used, and at such times the screw is very likely to be misplaced and lost; altogether, such a connection is not to be recommended. Another mode of connection much better adapted to light lathes than either of the previous is that of frictional contact, caused by jamming the pulley against the wheel by means of a large nut and screw-thread upon the spindle at the other side of the cone-pulley and small pinion. The connection is made by screwing this nut tight up against the pinion, thus forcing the pulley against the spur-wheel; and the two are disconnected by screwing the nut backwards against a collar on the lathe-spindle, so that the pulley, being no longer jammed between the nut and wheel, is enabled to rotate freely upon its spindle. This latter connection is very easily made and unmade, and the balance of the moving parts is not affected in any way. The reader knowing a little of mechanics will probably ask why a series of wheels are used to reduce the speed and increase the power, when a single wheel with an endless screw gearing into it would do so with much less complication, and this obvious simplification appears so plausible that it has been many times tried. The friction, however, of the worm and worm-wheel is much greater than that of the train of wheels,

and absorbs so much of the driving power, that the latter mechanism is for such purposes almost always used in preference, notwithstanding the simplicity of the former. This is not, however, the case when a reduction of speed is the only object to be attained, and very little resistance has to be overcome.

The power a man can exert in treading in the manner required to give motion to a lathe is after all but very little, and although this may be multiplied by means of the mechanism just described, the range of such mechanism is much too small for the purposes of the mechanical engineer. A man on ordinary work would probably exert in treading a lathe a force equal to about 2,000 to 3,000 pounds raised one foot high in the minute. A horse-power is invariably assumed to be equal to 33,000 lbs. raised the same height in the same time, so that in treading a lathe a man only exerts a force equivalent to $33,000 \div 3,000 =$ one-eleventh of a horse-power. This force aided by the double gear is enough for ordinary light metal turning, but when heavier work has to be performed it becomes necessary to employ either more men or some other motive power, such as that derived from a water-wheel or the steam-engine. When light work is the rule and heavy work the exception, and steam-power not at hand, it is in some cases advisable to employ two or more men; but in other cases steam or water power is in every way cheaper and more convenient. When men are employed they can either drive the lathe by means of a large wheel, as already described, or they can exert their strength upon the lathe-treadle. When the treadle is used in the ordinary manner, it is plain that the force can only be applied during the downward stroke of the treadle-board, and if much power be applied a very heavy fly-wheel must be employed to obtain the momentum necessary for carrying the crank onwards during the remainder of the stroke until the pressure can again be put upon the treadle-board. To obviate this necessity, and allow of the more effective employment of two or more men, lathes are constructed with two or more treadles, and the treadles are so arranged that one shall be rising whilst the other is being pressed downwards. Fig. 11 illustrates a lathe having such means of receiving the driving power, patented some years ago by Messrs. W. Muir and Co., Manchester. The manner in which the treadles are arranged is plain from the figure. The lathe shown has double treadles and cranks, and the two are connected by means of endless chains passing over trucks or small rollers with a view of lessening friction. This lathe has cast-iron standards and cast-iron bed. The driving-pulleys are grooved, and the motion is communicated by a gut. It also has double gearing, and an internal screw-puppet, and is altogether a plain and serviceable lathe.

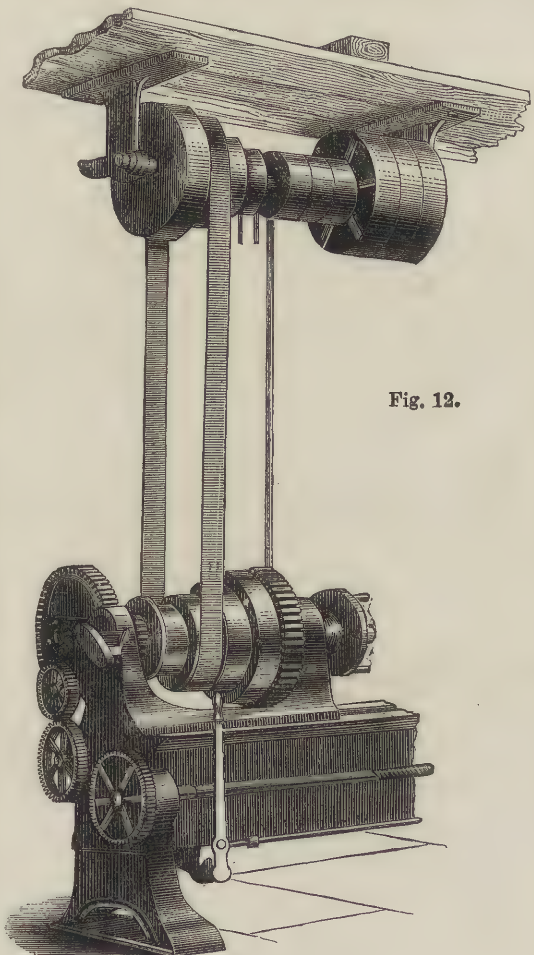


Fig. 12.

Gut-driving bands are used only for light lathes, for which they are extremely well suited. Heavier lathes, requiring more power, are driven generally by means of a flat leather belt, and the lathe-pulleys are also made flat instead of being grooved. Leather belts are strong and durable; they run quite noiselessly, and can be made to transmit any amount of power by having them of a suitable width. They should, however, always be well stretched before being cut to the required length, as otherwise it will be many months before a new lathe-belt will cease to give trouble by becoming too slack to transmit the power, and a good deal of the belt will eventually have to be cut off. The ends forming the joint should be cut rather thinner, so that the joint should not be too thick and clumsy, and if a little oil and powdered resin be thrown between the surface of the belt and pulley, it will hasten the production of a good working surface to the belt. This is a great desideratum, as new belts, being hard and stiff, cause a great deal of trouble by slipping.

When lathes are driven by steam, there is usually a main driving-shaft running through the workshop, and from this the power is transmitted to an intermediate shaft placed a few feet over the lathe-pulley. This intermediate shaft is driven at a constant speed by a leather belt; but it also carries a cone or stepped pulley corresponding to that on the lathe-spindle. The position of this countershaft and the mode of driving the lathe are shown plainly by Fig. 12, which scarcely needs any further description. In the figure the countershaft is shown with two sets of pulleys, in all six pulleys besides the cone pulley. It is therefore necessary to say that for driving an ordinary plain lathe, only one set of two pulleys is required, and the uses of the remaining pulleys will be shown hereafter. Of the two pulleys used, one only is fastened to the countershaft; the second is simply placed upon it without being keyed to it, so that the shaft and pulley may rotate quite independent of each other. The fixed pulley is termed the "driving-pulley," the loose one is termed the "idle" pulley. The idle pulley is kept against the other by means of a collar on the countershaft. There is a third pulley on the main shaft of the workshop of a size depending upon the speed of the shaft and the required speed of the lathe. A leather belt, rather narrower than one of the countershaft pulleys, passes round the main driving-pulley and the countershaft-pulley. Suppose the main shaft to be running, the leather belt would obviously communicate the motion to the pulley of the countershaft upon which it was running. If the belt were upon the fast or driving-pulley of the intermediate shaft, the shaft itself and consequently the lathe would be rotated also; but if the belt were running upon the idle pulley, that pulley would alone rotate, and the countershaft and lathe remain still. This expedient of fast and loose pulleys is the one generally adopted for starting and stopping the lathe driven by any external motive power, a lever and slide with a fork embracing the belt being employed for transferring the belt from one pulley to the other. By this means the motion is gradually imparted to the lathe and work, and there is no injurious shock or strain given to any part, nor is the stopping or starting attended with any disagreeable noise.

BUILDERS' QUANTITIES AND MEASUREMENTS.—V.

BY E. WYNDHAM TARN, M.A.

ABSTRACT OF DIMENSIONS.

We shall now give an abstract of all the dimensions tabulated in the last lesson (page 58), so as to show how they are to be prepared for bringing into bill :—

ABSTRACT.

		Superficial.								
Concrete. 1 of lime to 6 of ballast. c. ft. c. yds. 27)426($15\frac{3}{4}$ 27 156 135 21 6 in. concrete floor. Superf. ft. 9)446 $49\frac{1}{2}$ yds. 6 in. cement concrete. ft. 9)22 6 $2\frac{1}{2}$ yds. 9 in. ditto in walls, includg. use of apparatus. ft. 9)191 6 $21\frac{1}{4}$ yds.	Cube brick-work. ft. 23 0	Add. 1 bk. ft. 94 47 47 23 6 2350 164 126 980 6 108 94 3 47 2 4081 5 201 9 3879 8 2 3)7759 4 2586 5 838 0 rd. ft. 272)3424 5(12 160 272 704 544 160..........	Add. $1\frac{1}{2}$ bk. ft. 23 6 47 23 6 987 14 32 6 1127 6 289 1 838 5 .Fence wall. ft. 292 6 2 3)585 195	Ddct. 1 bk. ft. 72 114 9 15 201 9	Ddct. $1\frac{1}{2}$ bk. ft. 59 29 19 6 118 2 63 5 289 1	Superf. Asphalte. ft. 86 1 bk. nogging. ft. 161 144 8 9)305 8 34 yds. $\frac{1}{2}$ bk. trimmer. 10 6 7 6 18 0 Malm facing. ft. 9)808 5 $89\frac{3}{4}$ yds. Malm cutter arch. ft. 76 8 1 bk. vault. ft. 9)66 6 $7\frac{1}{2}$ yds...	Superf. Tuck pointing. ft. 9)1006 112 yds. Flat jt. pointg. ft. 9)2077 231 yds. Splay. ft. 20 5 $\frac{1}{2}$-inch tile, paving in cement. ft. 9)895 6 $99\frac{1}{2}$ yds. ... bk. on edge paving. ft. 9)35 9 4 yds.	Runs. I. hooping, $1\frac{1}{2} \times \frac{1}{16}$. ft. 3)1128 376 yds. W. I. chimney bar, $2\frac{1}{2} \times \frac{1}{2}$. 45 ft. Chamfer to brickwork. 31 ft. Double tile creasing. 32 ft. Extra to bk. on edge coping in cement 65 ft. 6-in. pipe drain. 60 ft. Chase for R. W. P. ft. 22 6	Nos. Flues cored. 6 Chy. pots. 6 Setting range. 1 Setting stoves 5 Beddg. and pointg. frames. 12 Air-bricks. 8 6-in. junction to drain. 3 6-in. bend. 2 6-in. syphon-trap. 1

The abstract is now ready for bringing into bill, which being the last process in the operation of taking out quantities, or of measuring work that has been executed, is not performed until the whole of the trades have been abstracted; we shall, therefore, place the bill at the end of this series of lessons, and then bring all the trades together into one bill.

TILER AND SLATER.

When tiles or slates are used as the covering for a roof, the measurement is nearly the same in every case, being taken by the square of 100 superficial feet. In measuring plain tiling, take the length along the eaves by the depth on the slope, with 6 inches over if there are dripping eaves, and 4 inches for other eaves. Measure the length of the valleys by a width of 1 foot, and add it to the superficial area; also take the length of all cuttings by 3 inches wide for a superficial measurement. Describe the width which the tiles show on the face, whether 3 or 4 inches, the kind of laths, nails, etc. Where there is a barge-board to the gable measure its length as run of heading. Flat roofs formed of plain tiles, of two or more courses in cement, are measured also by the square of 100 feet. Ornamental ridge tiling is taken by the foot run, and its character or pattern described by a sketch in the margin of the bill; other ridge tiling or hip tiling is taken in the same way.

Ornamental or patent tiling is measured by the square, and described, or a sketch shown.

Pan-tiling is taken by the square, but no allowance is to be made for eaves; the gauge is stated, and whether laid dry or in mortar; also if pointed on the outside. Heading to gable-ends, ridges, hips, and valleys, filleting, etc., are taken by the foot run. Take the number of the hip-hooks and T-nails, including painting.

When a triangular piece of tiling or slating has to be measured, as in a hipped roof, take the length of the eaves by half the depth of the slope, measured at right angles to the line of the eaves.

There are several kinds of slates used for roofing purposes, and the quality must therefore be described; the measurement is the same as for tiling, by the square. The amount of lap, and the kind and size of nails used, must also be stated. In taking the width of the slating, allow an extra amount equal to the gauge of the slates, if laid double at the eaves. Slating is sometimes pointed on the under side with mortar, which is included with the superficial measurement, and must be described. Deduct all openings in the slating for dormers or chimneys, and measure all cutting, the length by six inches in width, adding it to the superficial measurement. Circular work can either be measured net and described, or an allowance of one-third extra can be made for it, and added to the plain work.

If slating is laid on asphalted felt, the felt is measured separately, by the square. Sawn slate hips and ridges are taken by the foot run. Slate slabs, when used as shelves, cisterns, steps, etc., are taken by the foot superficial, describing the thickness, and whether planed or rubbed. Grooving, moulding, rounding, etc., to sawn slate is taken at per foot run, describing the thickness.

The following dimensions will serve to illustrate the measurement of tilers' and slaters' works:—

2)	31 6 14 4	903 0	Plain tiling, showing 4 inches, on double fir laths and wrought nails.
	15 0 7 4	110 0	Add hip.
	19 6 1 0	19 6	Add valley.
		1032 6	
2)	14 0	28 0	Heading to barge.
	31 6	31 6	Ornamental ridge tiling.
	9 6 6 6	61 9	Flat roof of 2 courses plain tiles in cement.
2)	31 6 14 0	882 0	Pan-tiling to a 10-inch gauge, bedded in mortar, and pointed.
2)	14 0	28 0	Heading to barge.
	28 0	28 0	Cement filleting.
	45 0	45 0	Hip and ridge tiles in cement.

No. 2 hip-hooks and painting.

2) 31 6 14 8	924 0	Countess slating, $2\frac{1}{2}$ inch lap, two $1\frac{1}{2}$-inch copper nails to each slate, and pointing the underside.
2) 18 0 1 0	36 0	Add for cutting to hips and valleys.
15 0 6	7 6	Ditto ditto round chimney.
	967 6	
6 0 1 6	9 0	Ddct. opening for chimney-stack.
5 0 3 0	15 0	Ddct. skylight.
	943 6	
45 0	45 0	Sawn slate hip and ridge, and fixing with white lead and copper screws.
2) 31 6 14 8	924 0	Asphalted felt laid under slates.
24 0 1 3	30 0	$\frac{3}{4}$-inch sawn slate shelf, planed.
24 0	24 0	Rounded nosing to $\frac{3}{4}$ shelf.

ABSTRACT.

Superf. Plain tiling, 4" inch on face, double fir laths, wrot. nls. ft. 100)1032 6 $10\frac{1}{3}$ sqrs.	Superf. Pantiling, 10-inch gauge, in mortar and pointed. ft. 100)882 0 $8\frac{3}{4}$ sqrs.	Superf. Countess slating, $2\frac{1}{2}$ lap, two $1\frac{1}{2}$ inch copper nls., and pointing underside. ft. 100)943 6 9 sqrs. 44 ft.
Superf. Flat roof of 2 courses plain tiles in cement. ft. 61 9	Run. Heading to barge. ft. 28 0	$\frac{3}{4}$-inch sawn slate shelf planed. ft. 30 0
Run. Heading to barge. ft. 28 0	Cement filleting. ft. 28 0	Asphalted felt. ft. 100)924 $9\frac{1}{4}$ sqrs.
Ornl. ridge tiling in cement. ft. 31 6	Hip and ridge tile in cement. ft. 45 0	Run. Sawn slate hip and ridge, fixed with white lead & copper screws. 45 ft.
	No. 2 hip-hooks and painting.	Rounded nosing to $\frac{3}{4}$-inch shelf. 24 ft.

OPTICAL INSTRUMENTS.—XVI.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

Gasometers and Gasholders.—As the lime-light is employed by the photographic enlarger as well as the lantern exhibitor, the special requirements of each must be considered when selecting an outfit. A lantern exhibitor in the course of a couple of hours completely uses up the six or eight cubic feet his bags are stored with; not so the photographer, who often only brings his apparatus into use for a few minutes, and often with many days' interval. Now it is well known that, if the gases are kept in bags for several days, both oxygen and hydrogen will be found deteriorated in quality, through atmospheric air having passed, by an endos- and exos-motic action, through the pores of the cloth and mixed with the contained gas. Again, as the gases are seldom rendered chemically pure, if they are left in the bags for any time the india-rubber cloth is attacked, and after a little time is rendered rotten, by their corrosive action, especially in the case of oxygen, which seldom comes over without traces of free chlorine. Metal reservoirs are, therefore, better suited for the work of the photographer, as portability is not an essential, especially as they can be put into a neat and compact form that stands in a fixed position ever ready for use. But there is still another class of operators to whom gasometers or gasholders would be preferable to gas-bags, namely, those who reside abroad, for the reason that, in very hot or very cold climates, india-rubber cloth rapidly deteriorates in quality, or cracks through being hardened by a continuous low temperature. Again, in places infested by cockroaches, those invertebrate gourmands manifest such an extreme affection for gas-bags, that if they get the chance of making their acquaintance they never fail to "make them one of themselves."

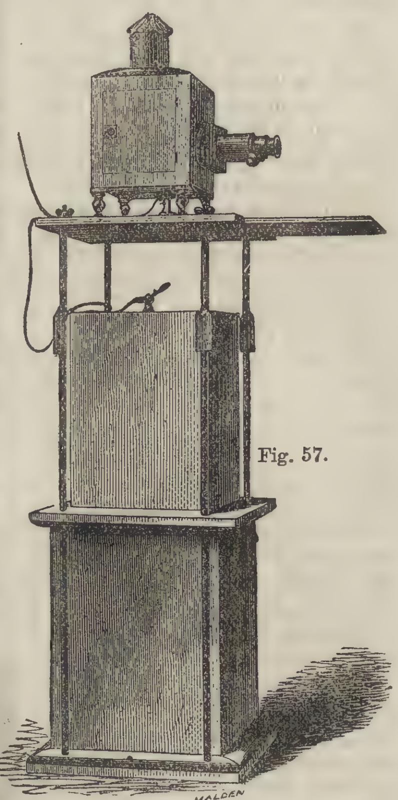


Fig. 57.

In a paper read before the Society of Arts in 1863 (just after the close of the International Exhibition, where I displayed the apparatus referred to), I described and figured a form of gasometer here reproduced (Fig. 57), which would be found extremely useful in a photographer's enlarging room, as it not only stores the oxygen for an oxy-calcium jet, but forms a solid support for the enlarging lantern. This I originally designed for a professor's lecture-room, where only small quantities of oxygen were required at a time, for the display of an occasional diagram in illustrating a course of lectures, and to avoid the daily or frequent production of oxygen.

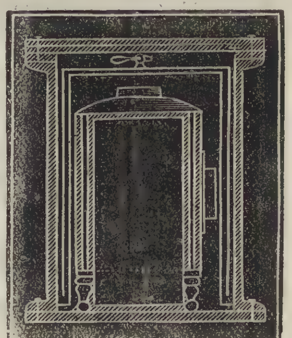


Fig. 58.

Fig. 58 shows how I contrived this arrangement, so that the lantern could be packed in the body of the gasometer for travelling, if necessary, a matter of consideration for the wants of the Indian colleges, where the apparatus is sent from one professor to another, at distant stations.

When unpacked and arranged for use, as shown in Fig. 57, it will be seen the "bell" that holds the gas is square instead of cylindrical, the form in which gasometers are usually made, slides up and down, in a double casing, shown in section in Fig. 58, that is filled with water, to form an air-tight water-joint for the rim of the bell, and to reduce the bulk of water required for this purpose to a minimum. The bell and water reservoir are both made of sheet zinc, the reservoir being strengthened and protected by an outer casing of wood that forms a packing-case to the arrangement (as shown in Fig. 58). Four iron rods fit into wooden fillets; on to the rods the flap lid of the packing-

case is screwed, to form a table for lantern and apparatus. At the top corner of each rod a pulley-wheel is inserted, over which cords attached to the four corners of the bell pass; to the ends of each cord counterpoise weights are suspended to keep the bell from "wobbling." A stop-cock is inserted in the middle of the top of the bell by which the gas is introduced, as well as drawn off. Before filling a gasometer the bell must be pushed down till its top comes in contact with the water that covers the roof of the reservoir, so that all air may be first driven out. When in work the necessary weights are placed on the top of the bell. When packed the four rods are strapped together, and the whole packs into a space of 15 inches square by 24 inches in height.

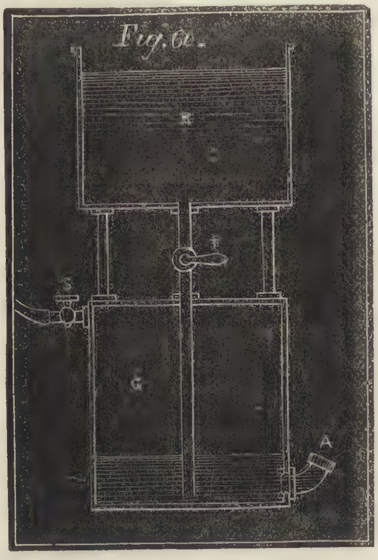


Fig. 60.

In the arrangements for storing gas, previously described (with the exception of the self-acting hydrogen generator), pressure has been obtained by the employment of iron weights, etc. I shall now proceed to discuss the merits of gasholders wherein water pressure is used.

The first arrangement I shall describe consists of an inner closed chamber, O (Fig. 59), that receives the oxygen gas, placed within, and communicating by openings at the bottom with an outer one of equal capacity open to the air. At starting, the inner chamber, O, is filled with water, which is displaced on introducing the gas through the tube I, being driven into the outer chamber, and carried away by a waste-pipe at P, to a pail or sink. The outer chamber, W, remains full of water. The height of this apparatus should be about five feet, and the diameter of the inner chamber one foot. On connecting the inner chamber with the jet, and opening the tap T, the water passes from the outer to the inner chamber, and rising, drives out the oxygen under a pressure which, however, is constantly diminishing. Of course this action would come to a stop when the water finds its level, unless the water previously displaced can be returned to the outer chamber; and this may be effected by putting a pail, filled with water, on a shelf placed at a suitable height, and letting the water flow into the outer chambers of the gasometer, till both compartments are again filled, and the inner one emptied of gas. By proper adjustment of the flow, by means of a small ball-cock arrangement, a constant pressure could be obtained.

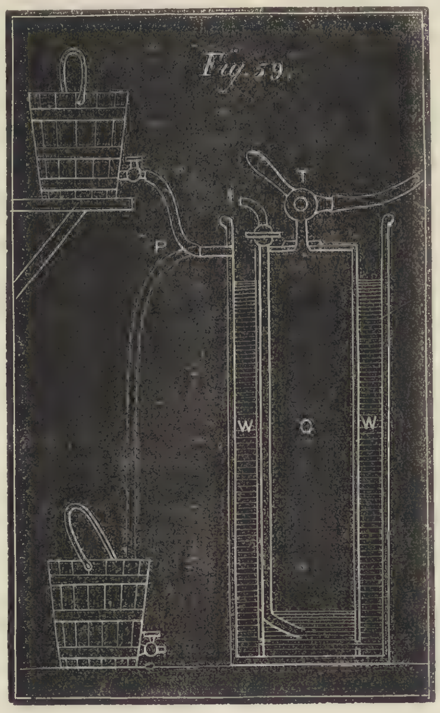


Fig. 59.

It is a question, however, whether a Pepys' gasholder, modified so as to make it portable, would not be a preferable arrangement, especially for replacing gas-bags in foreign climates. This likewise consists of two chambers, as shown in Fig. 60, only placed over instead of being parallel with each other. The compartment G is filled with water from the reservoir, R, till it runs over at the tap, S, which is then closed, as is also the tap, T. The delivery-tube of the gas-generating apparatus is introduced into a tubular opening at A, till the gasholder is filled; it is then removed, and A is closed with a screw-cap fitted with a washer. The reservoir, R, is again filled with the water displaced from G, the tap, T, is opened, and on the stop-cock, S, being opened the gas is driven out under pressure. The amount of pressure may be varied according to the height the water reservoir, R, is placed above the bottom of the gasholder, G, but a tube three feet in height would give sufficient for all ordinary purposes. Whatever be the size or shape of a gasholder, a column of water 33 feet in height would give a pressure of 15 lbs. on the square inch. The gasholder represented in Fig. 60 is made portable for travelling by arranging the diameter of G to be somewhat less than that of R, so that the former can pack inside the latter when the taps, S, T, and the tube, A, are unscrewed and the two chambers disconnected by unscrewing the three pillars that support them one above the other when fitted up for use.

The secret of safe manipulation does not rest so much in the construction of the jets employed for the lime-light as in a perfect perception on the part of the operator that atmospheric air must never be allowed to mix with the gases: therefore both generators and gas-bags, etc., must be perfectly emptied of air before commencing work, as previously described; that pressure must be constantly kept upon the gas-bags, gasometers, or gasholders, before their taps are opened, and during the whole time the gases are ignited at the nozzle of the jets; that when the two gases are employed with the oxy-hydrogen jet, an equal pressure must be kept upon each reservoir, for if the pressure becomes unequal, either through having a weight on one receptacle and not on the other, or through having a hundredweight on one and a half-hundredweight on the other, or setting up unequal pressure through unequal leverage by an improper distribution of the weights, or by one pair of pressure-boards being longer than the other, or converting human beings into weights (most dangerous substitutes), etc., then the gas on which there is the greatest weight or leverage will be forced over to the other gas receptacle as soon as a free communication is established through the connecting-tubes when the taps are opened, and an explosive mixture will be formed, which most assuredly will ignite, should the weight be removed from the weaker bag or other receptacle while the gases are burning at the nozzle, and an explosion of considerable force will then result. Nearly every accident of the nature here indicated, of which I have been able to trace the history, has resulted from inattention to these simple rules, through weighting the bags with things of indefinite weight—such as a fender on one bag and fire-irons on the other—then trying to correct the defectiveness of the light by pressing the bags with the hands, which has resulted in an explosion as soon as the hands have been removed.

One curious circumstance connected with such explosions is, that I have never heard of their causing *personal* injury; though the pressure-boards have been shattered to splinters, a heavy door taken off its hinges, every pane of glass in the windows of the room blown out, yet, with ten or more people standing round the apparatus, not one has been hurt. I believe that, if a sufficient pressure were kept up on a bladder filled with a mixture of oxygen and hydrogen, the gases might be ignited at the nozzle of the jet without fear of an explosion. The whole secret of safety lies in a nutshell. Keep the oxygen and hydrogen in separate bags; always have sufficient and equal pressure on both bags, and never remove the weights from either bag while the gases are burning. As it is simply impossible to form an explosive mixture with the oxy-calcium arrangement, of course I enforce the above rules in reference to the use of the oxy-hydrogen jet.

MINING AND QUARRYING.—XVI.

BY GEORGE GLADSTONE, F.C.S.

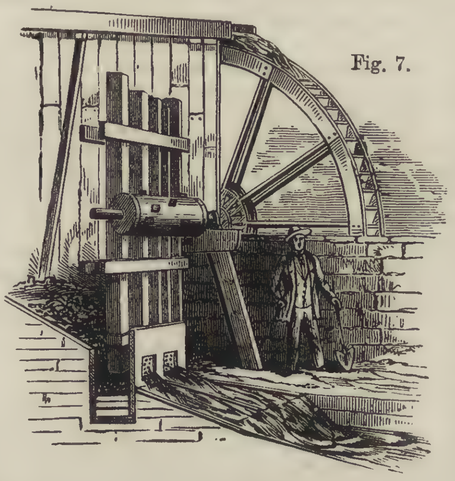
TIN (*continued*).

MINING UNDER THE SEA — DRESSING-FLOORS — STAMPING — WASHING — VANNING — CALCINING — SEPARATION OF WOLFRAM—BLACK TIN—SAMPLING—TICKETING.

MUCH ingenuity and spirit is exhibited by the miners of Cornwall and Devonshire in the pursuit of the underground riches. In many instances, too, they have shown a remarkable amount of daring, and of perseverance under circumstances of no ordinary difficulty.

The neighbourhood of Penzance was the scene of one of these, where, towards the close of the last century, when the science of engineering was far behind what it is now, a working miner conceived the project of opening a mine on a sand-bank, covered by the tide at high water. A very rich lode of tin was known to pass under the inlet of the sea, because it could be traced in the land on both sides of the bay, and had long been worked as far as it was exposed on the fall of the tide. The spot fixed upon for the workings was about 700 feet distant from the shore; and here the shaft had to be carried upwards till it reached a level above that of the highest spring tides, as well as downwards into the rock: here exposed to the violence of the waves, and to the constant percolation of the water through the woodwork of the shaft, as well as through the fissures of the rock, ore to the value of £70,000 is said to have been raised. An American ship, unfortunately, drove against the works one day in a storm, and this romantically situated mine came to an untimely end.

Fig. 7.



Another mine, from which a large quantity of tin as well as copper has been extracted, is situated at the extreme point of land overlooking the Atlantic. The entrance to Botallack mine is about midway between the top of the cliff and the sea; and the underground excavations follow the lodes out seaward to a distance of about 500 feet. Not only do the miners here run the risk of cutting into some fissure which would admit the sea-water at a greater rate than the engines could pump it out, which would lead to the mine being irremediably drowned; but the exposed site of the shaft-heads, with their engines and other works, which are dotted about the face of the cliff, greatly enhances the cost of the works and the labour of the miners.

When the tin-stone has been brought to the surface, or to *grass* as it is locally termed, it has to undergo a variety of processes to prepare it for the market, which are all included in the general term "dressing." Most of these are more or less dependent upon the great weight of the ore as compared with the gangue, or earthy part of the lode. The only article commonly associated with the tin which is its rival in specific gravity is wolfram, so that when this is present special means have to be adopted for its separation.

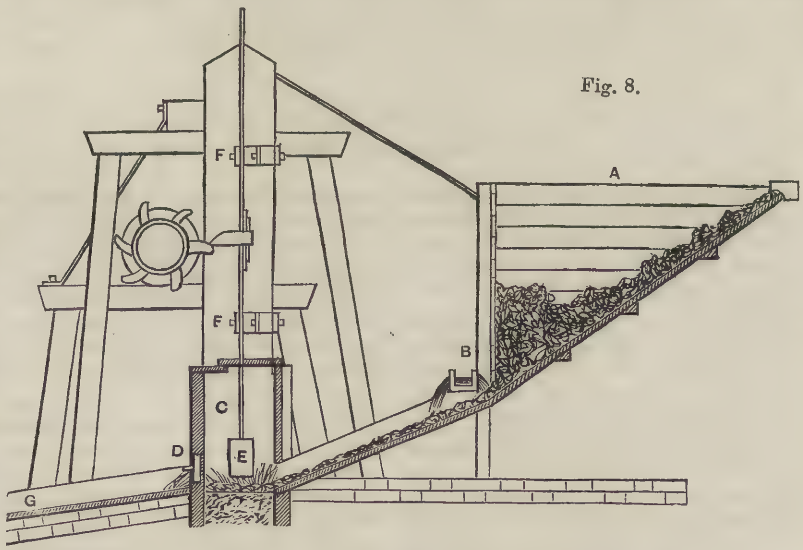
Water is the most indispensable article at the dressing-floors, and if a large natural supply is not at hand it must be brought to the spot. The level at which the water is brought in should be considerably above that of the floors, as a good fall is always advantageous.

The ore arrives at the surface in lumps of various sizes, and just in the condition in which it has been shovelled up after a blasting—associated with much dust and dirt. It is therefore customary to wash it first, by passing a stream of water through the heap, which carries away the useless substances. It can then be readily seen what pieces of the stone are valueless, and these are picked out and thrown aside: other lumps may contain a portion of tin-stone associated with a good deal of rubbish, and these are broken with a hammer into smaller pieces, and the useless portions rejected. All the larger lumps of tin-stone are broken up at the same time into pieces of more convenient size, preparatory to their undergoing the next operation.

The ore is so generally disseminated throughout the gangue, and consists of such fine grains, that it cannot be separated by hand; and in order to free it from the earthy substances, the whole of the stone must be finely pulverised. This is ordinarily done by stamping. In former times the stamps were driven by water-power, but now the aid of steam is more commonly accepted, and much larger stamping-mills are now to be seen than when water was the motive power.

Fig. 7 will serve to illustrate the simplest form, constructed for the most part of wood, and driven by a water-wheel. Fig. 8 is the section of an improved form. The stone to be crushed is supplied gradually from the hopper, A, by the agency of the water which pours from the launder B, carrying the stone with it down the slope into the cofer C, where it comes under the stamps, and is crushed by them until fine enough to pass through the gratings at D. These are usually made so fine as to contain 160 apertures in the square inch. The stamp-head, E, is always made of iron, and in the second diagram it is attached to an iron rod, which works through guides, F F, by which its action is steadied. The mode of arranging the cams for lifting the pestles is best seen in Fig. 8, where it will be found that they are so placed upon the drum, as to produce a constant uniform strain upon the driving apparatus: attention to this point not only economises power, but also prevents unnecessary wear and tear. In large works there will be 100 or more stamps, and each stamp-head will weigh about five hundredweight. When steam is the motive power the stamps are driven very quickly, each head giving from forty to eighty blows per minute, according to the nature of the rock to be crushed, with a fall of seven to eight inches. The water which flows through the cofer not only feeds the stamps on the one side, and carries off the powdered rock through the gratings on the other, but also serves the important

Fig. 8.

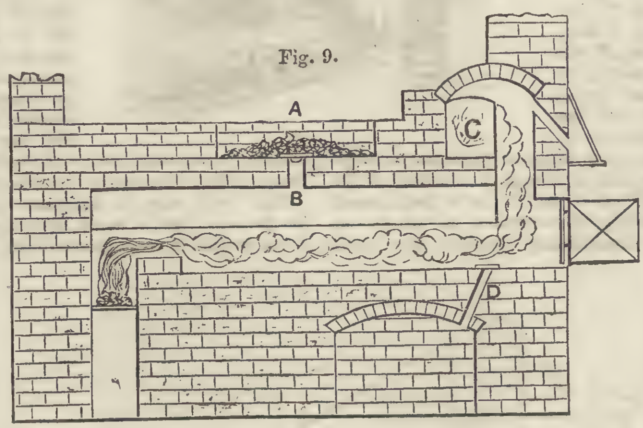


purpose of keeping the stamp-heads cool. When the tin-stuff is sufficiently pulverised to pass through the gratings, it is carried by the water down the trough, G, which leads to two basins, one in front of the other. The heavier portion, or "roughs," consisting of little else than oxide of tin, is deposited in the first basin, while the lighter portion, or "slimes," is carried forward to the second. Both deposits are subjected to further washings in order to remove the earthy portions; for which purpose a great variety of different machines have been invented, all, however, based upon the principle of the more rapid subsidence of the metalliferous portion as compared with the rock, when agitated in water.

How certainly it acts may be illustrated by the simple process of vanning, which is frequently adopted when it is necessary to ascertain roughly the character of a pile of stuff from the stamping-mill. A little of the pounded stone is taken up on a shovel that is rather hollow in the middle, and then by causing a little vibratory motion, and dipping it at intervals under the surface of some water, the contents are separated; the tin ore collects on one side of the shovel, the copper ore in the centre, and the waste, which is the lightest, on the opposite side.

The rack or frame is but an adaptation on a large scale of the vanning-shovel. It consists of a long table on a slight incline, down which the slimes are carried by a gentle stream of water, the mixture being continually agitated either by an attendant or by machinery. The purest ore, called "heads," collects at the upper part of the table; a second quality, or middles, lower down; while the tails occupy the extreme end. The middles are usually submitted to the same process a second time, but the heads are sufficiently pure to render this unnecessary.

Fig. 9.



Any wolfram that may be mixed with the ore will be found in the roughs and heads, being slightly heavier than the oxide of tin itself. Copper and iron pyrites, which are commonly found in all lodes, remain more or less mixed with the tin-stuff, as their specific gravity varies from 4·2 to 5·0; and many of the ores contain arsenical pyrites also, called "tin whits" by the miners. These various substances must be thoroughly separated, and with this object the ore is sent to the calcining furnace. This is made on the reverberatory principle, as the flame from these furnaces is highly oxidising. The ordinary form is shown in Fig. 9.

The crushed ore is first put into the **drying-bin**, A, where it remains till all the moisture is driven off, when it is allowed to fall through the funnel B upon the hearth. The furnace is got up to only a very moderate heat at first, and then gradually increased, care being taken not to exceed a dull red heat, or otherwise the ore would begin to cake together, which would entail both trouble and expense in reducing it again to a powder. The workman rabbles the ore every twenty minutes or so, for the purpose of exposing all parts of it more thoroughly to the action of the flame, and the process is repeated until the white fumes, which have been given off in quantity, cease to appear. These fumes contain much of the sulphur and the arsenic, which have been expelled from the pyrites; and they are carried through a long series of chambers, C, in which the arsenic is deposited on cooling before reaching the chimney. Thus an article of value is obtained, which, if allowed to escape at once into the air, would have a very deleterious effect upon the neighbourhood around. The ore, when sufficiently calcined, is raked through the channel D into the vault below; and is there exposed to the action of the atmosphere for a few days to promote the oxidation of the remaining sulphides into sulphates. The latter, being readily soluble in water, are then removed by washing. The ore is subsequently racked again in the same manner as previously to calcination, and is then fit for the smelter. In some of the large tin mines the calcining furnace is so arranged as to feed itself, and the stirring of the ores is done by machinery, so that it requires no attention beyond that of keeping up a sufficient supply of the tin-stuff in the hopper above.

When wolfram is present in the ore (but it is only in certain mines that such is the case in any quantity), an additional operation is necessary. Wolfram consists chemically of a tungstate of iron and manganese, forming the heavy crystalline insoluble body which has already been mentioned; and it was formerly regarded as so troublesome and deleterious an ingredient, that it used to depress the value of the tin ores of Drake Walls mine (where wolfram is particularly abundant) by 25 per cent. By the adoption of the following simple process the ores from this mine are rendered at least as pure as those of any other in the county; and the tungsten thus separated from the tin becomes a source of income, instead of a loss. The ore having been crushed and dressed as usual, the exact per-centage of wolfram is ascertained by analysis. The ore is then mixed with a sufficient quantity of soda ash, to supply an amount of soda which shall form the chemical equivalent of the tungstic acid in the wolfram. The mixture is then thrown into a reverberatory furnace, and brought up to a dull red heat. This roasting causes the oxidation of the iron and manganese in the wolfram, and at the same time the transfer of the tungstic acid from the former to the alkali, forming a tungstate of soda, which is perfectly soluble in water. After the product of the furnace has cooled down, it is lixiviated in water, by which the soda salt is dissolved out; and the liquor on being evaporated down yields crystals of tungstate of soda. The oxides of iron and manganese, being of much less specific gravity than the tin ore, are removed in the course of the usual rackings subsequent to calcination. The furnace used in this process is of somewhat different construction, the sole being made of iron instead of brick, as the soda ash would attack the silica in the fire-bricks, and carry with it some of the tin also; so that in such case, if fire-bricks were used in the construction of the furnace, there would be some loss of metal, while that which remained would be less valuable, owing to the imperfect removal of the tungstic acid.

The ore, although it has lost its original darkness of colour in the process of calcination, is known in the trade as black tin. Under this name it is sold to the smelters. There are periodical sales at the chief mining centres, prior to which the smelters send their assayers to draw samples of the different parcels. The most exact mode of ascertaining the per-centage and quality of metal in the ore, is to take two ounces of the black tin, and put it in a crucible, with two-thirds of an ounce of culm, and four pennyweights of borax. On subjecting the crucible to a strong heat the metallic tin separates, and the button of metal collects at the bottom of the crucible. This is weighed to find the quantity; and then hammered, its behaviour under the hammer being a sufficient test of its quality.

A more expeditious plan, and one which answers the smelter's purpose equally well, as it returns about a similar proportion of metal to what will be obtained in the regular operations on a large scale, is to mix the sample with about 4 per cent. of pounded coal, put it into an open crucible, and subject it to a high temperature in an air-furnace for a few minutes, when reduction will take place. This plan will return about 5 per cent. less metal than the preceding.

On the day appointed for the sale, the smelters send in their tenders (or "tickets," as they are called in Cornwall), and the highest of these are accepted. Sometimes the black tin is sold by private contract. The produce of most of the streamings, as well as of the small mines which do not raise sufficient ore to make it worth while to erect dressing-floors, is sold in an undressed state by private bargain.

PHOTOGRAPHY—III.

By J. C. Leake.

MANIPULATION OF PLATES FOR TAKING PICTURES.

We may now suppose that the dark room or operating chamber has been duly prepared, as well as the camera, stand, and other apparatus already described; that all the solutions are ready mixed, according to the foregoing instructions; and that the photographer is now ready to commence the taking of pictures. We will therefore proceed to describe the manipulations necessary for the purpose. The first operation will be the cleaning of the glass plate required for the support of the sensitive film of iodide of silver. With respect to the quality of the glass employed, we should advise the use of that known as "patent plate," as, although somewhat expensive at the outset, it will better bear the frequent removal of the film which will be required in case of failure than any of the cheaper varieties. Besides this, a defective glass is a frequent cause of failure, and it is well to reduce the chances of this to the smallest number, in order that they may be more readily traced to their cause, and remedied. Before cleaning the glasses they should be slightly ground on their edges, in order to prevent accidents to the hands when in course of manipulation; this is best effected by rubbing them lightly with a piece of ordinary whetstone, kept damp with water. After this, they should be well washed in abundance of water, and roughly dried with a coarse cloth. A plate may now be fixed in the vice before described, and a few drops of the plate-cleaning solution poured upon it in the centre. This should be applied to all parts of the plate, by means of a tuft of cotton wool; the remaining portion may then be removed by rubbing with a clean soft linen cloth, and the final polish imparted with the prepared soft leather. Both sides of the plate should be thus treated, but that upon which the collodion is to be spread should be tested for cleanliness by breathing upon it. If the breath is condensed in a perfectly smooth and even sheet, without marks and lines, the work of cleaning may be considered as complete and satisfactory, but should any stains or marks appear, the operation of polishing with the leather should be repeated. It frequently happens that beginners clean a plate and rub it until it is dirty. The operation of cleaning is rapidly effected, if proper precautions such as we have stated are taken; and nothing whatever is gained by a long continuance of the process. When the plate is cleaned it should be lightly brushed, to remove any dust which may adhere to its surface, and placed in the grooved box prepared for its reception, taking care to place the best side towards one end which has been marked, so that as each plate is removed the operator may be sure of having that side which is best prepared uppermost. At least six plates should be cleaned before work is commenced, both in order to save time in operating, and to prevent any chance of contaminating the cloths and leathers with the chemicals employed in subsequent parts of the process.

When a sufficient number of the plates have been prepared, enough of the nitrate-of-silver solution should be poured into the bath to rather more than cover the plate, having first rinsed out the vessel with distilled water. The surface of the solution should then be skimmed with a slip of writing-paper, in order to remove any dust or scum which may arise. Into one of the developing-glasses should be poured sufficient of the iron developing solution to cover the plate amply and readily, say two or three fluid ounces; while the second developing-glass should contain about half the quantity of the pyrogallic acid solution, for intensifying. If the water is not laid on into the developing-room, a sufficient supply should be provided in a tub or pail, and a large spouted jug should be placed ready for use. Before proceeding to prepare the sensitive plate, the camera should be arranged in front of the scene to be photographed; and we should advise the tyro to select a tolerably well-lighted view of a building, in partial sunlight, for his first experiment. He should by all means avoid portraiture and difficult subjects, such as foliage or any objects at all likely to move, until such time as he has acquired so perfect a mastery over the instruments used and the chemicals employed as to ensure success as far as these are concerned. The more simple the first experiments are the greater will be the probability of success, and the transition from easy to difficult work will be readily effected as the operator becomes used to his tools. When the camera has been placed in position, and firmly screwed to the stand, the cap of the lens should be removed; and the head of the operator and the ground glass of the camera being enveloped in a dark cloth, in order to exclude the light, it will be observed that upon the ground-glass screen there will be an image more or less distinct of the scene before the camera. This image must be rendered perfectly sharp upon the screen before taking the picture. A rough adjustment may be made by drawing the camera out or closing it, as may be required; but the final one must be made by means of the rack-and-pinion movement of the lens itself. Too much care cannot be taken with this part of the work, as unless the picture be accurately focussed, it will appear blurred and "out of sharp." Of course the camera may be turned to the right or left, so as to include the required view; but any tilting from back to front is not allowable in the ordinary course of work, as this would cause a divergence of the lines in a building, and impart to it an appearance of falling. Of this difficulty and its remedy we shall treat farther on. The camera having been thus arranged, the operator may leave it in position, and proceed to the preparation of the sensitive plate.

The operation of coating a plate with collodion is one which requires some little practice before it can be successfully performed. The two great mistakes which the tyro is likely to make are, first, that of needlessly hurrying the operation; and secondly, that of trying to cover the plate with an insufficient quantity of the fluid. It is true that the coating should be effected quickly, but there is plenty of time to do it steadily, while there is far more danger of spoiling the work by over haste than by a too deliberate method of working. The coating may be performed by daylight, and, consequently, upon entering the operating chamber the yellow screen should be removed from the window before the work is commenced. One of the cleaned plates should be removed from the box by the corners, taking care not to touch the prepared surface with the hand, which would be certain to leave a stain. The operator should stand before the window, and holding the plate with the left hand, and by the lower corner, place it at such an angle with the light as may enable him to see any speck of dust or defect which it may bear upon its surface. The plate should then be lightly brushed, in order to remove any adherent particles of dust on both sides, and of course taking the strictest care with that one which is to receive the coating of collodion. The bottle of iodised collodion should now be taken into the right hand, and the plate being held as nearly level as may be, a good-sized pool of collodion should be poured on to it, nearly in its centre. A gentle inclination should then be made towards the top right-hand corner, so as to cause the fluid to flow in that direction quite up to the edge of the plate. When this is accomplished, incline the plate to the top left-hand corner, and then back, so that the collodion flows back so as nearly but not quite to touch the thumb which holds the plate. Now incline the plate to the right, and holding the collodion bottle under the right-hand bottom corner, allow the excess of fluid to flow back into the bottle; at the same time raise the back edge of the plate, so as to allow the whole of the superfluous collodion to drain off, and impart a gentle rocking motion, in order that all the lines of draining may coalesce and leave a perfectly smooth and even film. It will be of no avail to try to produce a good picture upon a badly-coated plate, as any inequality of thickness will be sure to show in the finished negative. We should therefore advise the operator to make several attempts to perform this operation properly before he proceeds farther in the process, and not to sensitise any plate before he has become well skilled in coating it with collodion, and can effect it with ease and certainty. With a steady hand and practice, the knack of coating a plate will soon be acquired, and this is the first step to really successful work. After an even coating has been obtained, a few seconds should elapse before the plate is immersed in the sensitising bath, the proper time for which may be ascertained by lightly touching the lower corner of the coated surface with the finger. When the film is just set enough to bear a light touch, without receiving any impression of the finger, it will be ready for immersion in the nitrate-of-silver bath. At this stage of the process, a properly prepared plate will appear perfectly transparent, the film of collodion being so thin and even as to be almost invisible. There may be a slight bloom

upon the coated side, but it frequently happens that this is so slight as to render it difficult to decide between the plain and covered surfaces.

TECHNICAL DRAWING.—LV.

GOTHIC STONEWORK.

EARLY ENGLISH CAPITALS.

The capitals of this period are usually bell-shaped, and are often, especially in the smaller examples, quite plain, with the exception of a necking and one or two mouldings around the abacus. In such cases they are distinguished from the capitals of later styles, which will be spoken of presently. The bell is generally deeply undercut, which is a strong characteristic of the style. Sometimes the nail-head or dog-tooth ornaments are placed in the hollows between the mouldings. In the larger and richer specimens the bell is covered with foliage, which, springing direct from the necking, is curled over most gracefully beneath the abacus. The foliage, which, from the peculiarity already mentioned, is termed "stiff-leaved," is very bold and striking, and is sometimes so deeply undercut as to be at its upper part entirely detached from the bell. It consists mainly of varieties of the trefoil leaf, thus seeming to show a desire to *aim at* the representation of natural forms, which was so well *accomplished* in the following period, and of which the exaggeration and subsequent *decadence* is seen in the Perpendicular. In clustered piers the capitals follow the form of the pier, as they also adopt the same form in the single shaft, with the exception that multangular shafts have often circular capitals. The base consists of a series of mouldings; frequently of a deep hollow and fillet between two rounds, of which the lower one projects beyond the other. The base most frequently stands upon a double or single plinth, which in the earlier examples is square, having an angle covered with a leaf, which springs from the base and falls over the plinth. In later examples the plinth assumes the form of the base, and is either circular or polygonal. It is sometimes of great height, having a second series of mouldings below the base. The group (Fig. 479) from Stone Church, Kent, is an excellent specimen of Early English capitals, decorated with stiff-leaved foliage and the dog-tooth ornament, which, in this case, is seen between the mouldings of the arch, and is of a perforated character.

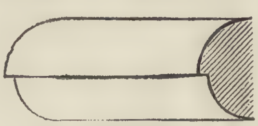


Fig. 485.

Fig. 486.

EARLY ENGLISH BUTTRESSES.

The buttresses of this period are for the most part of a simple character, consisting in smaller churches of two or more stages, the lower projecting beyond the other, each set-off being sloped at the top, so as to carry off the rain. Such a simple form of buttress is given in Fig. 480. The buttress finishes at the top, under the parapet or eaves, with a simple slope, similar to that of the other projections.

Fig. 481 illustrates a species of buttress used in larger buildings, which is frequently finished with a triangular head or gable. It is occasionally carried above the parapet, except where stone vaulting is employed, and in such cases it is covered with a pinnacle, which is either plain or ornamented. Sometimes each set-off is finished with a triangular head, and at others the water-table is continued round the three sides of the buttress. The edges of the buttress are often chamfered, as in the example, or the angles ornamented with slender shafts. Occasionally, too, the face of the buttress is sunk into a niche to contain a statue. This, however, is more a characteristic of the Decorated period than of the Early English. As in all the other features of Gothic architecture, the changes from one period to another were so gradual that great difficulty is found in distinguishing between the later portion of the one and the earlier portion of the other. Thus the exact date of a niched buttress would be doubtful were it not for other features connected with it. These will be pointed out in considering the next period. One great distinction must, however, be here noticed, namely, that at the angles of buildings of the Early English style the buttresses are placed at *right angles* to the walls, *as if each wall had been continued beyond the point of junction.* Thus *two* buttresses are required at each angle. In the subsequent periods, however, the buttresses at the angles were placed *diagonally*, and thus only *one* was required at each angle.

Flying buttresses (Fig. 482, from Westminster Abbey), which are arches springing from the wall-buttresses to the clerestory, were first introduced at this period, and are common in all large buildings with vaulted roofs. They are generally of simple design, with a plain capping and archivolt.

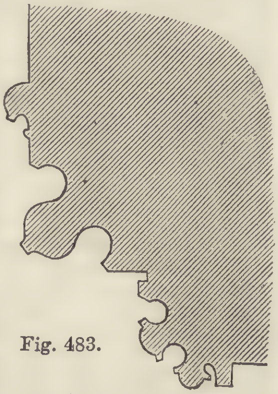


Fig. 483.

EARLY ENGLISH MOULDINGS.

We have seen that the plain square edges of the Norman arches were at first simply rounded off or chamfered. They were then cut into edge-rolls or "bowtells," with side-hollows. The side-hollows were then widened, and the edge-roll set forward on a small neck or shoulder. In the Transition period the bowtell and the roll and fillet were introduced: the mouldings generally became lighter and more numerous; but with the Early English a new principle sprung up in the character of the mouldings. This was the idea of obtaining effective combinations of light and shade by means of *under-cuttings.*

"To such an extravagant extent," said the Rev. T. N. Hutchinson, in his lecture on the subject, "was this carried during the early part of the thirteenth century, that the projecting members of a group of mouldings are often found only united to the arch by a mere neck or thread of stone. Such a combination of projecting rounds and deep hollows would present to the eye the appearance of alternate bands of light and shade, the depth of the hollows causing them to appear absolutely black. This arrangement would be tame and ineffective, were it not for its combination with the rectangular receding faces upon which Early English mouldings were generally cut. By this means a breadth of light and shade was introduced, and the uniformity caused by the alternating bands prevented."

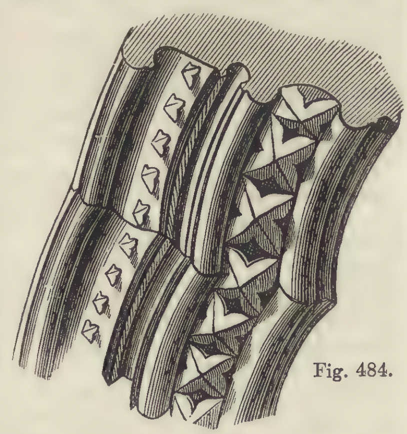


Fig. 484.

The several members of a group of Early English mouldings are generally of nearly equal size. Amongst them the roll and fillet and the pointed bowtell are of constant occurrence, as in Figs. 483 and 484.

About this time a new form of moulding was introduced, which became so generally used in the Decorated period as to form a characteristic feature. This was the "scroll moulding" (Fig. 485). Here again we must refer to the bowtell for its origin; it is, in fact, a bowtell, with one side of the fillet carried round so as to fill up the space between its height and that of the moulding.

The architects of the Decorated period gradually merged the edge of the fillet by a gentle curve into the face of the moulding; and at last it assumed the appearance, so peculiar to the fourteenth century, shown in Fig. 486. It will be seen, on comparing Fig. 485 with Fig. 486, that the angle formed by the edge of the fillet and the moulding below is converted, as it were, into a shallow groove.

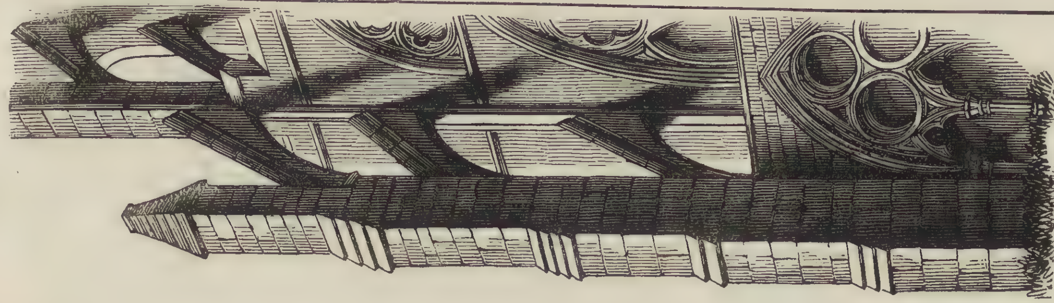


Fig. 482.

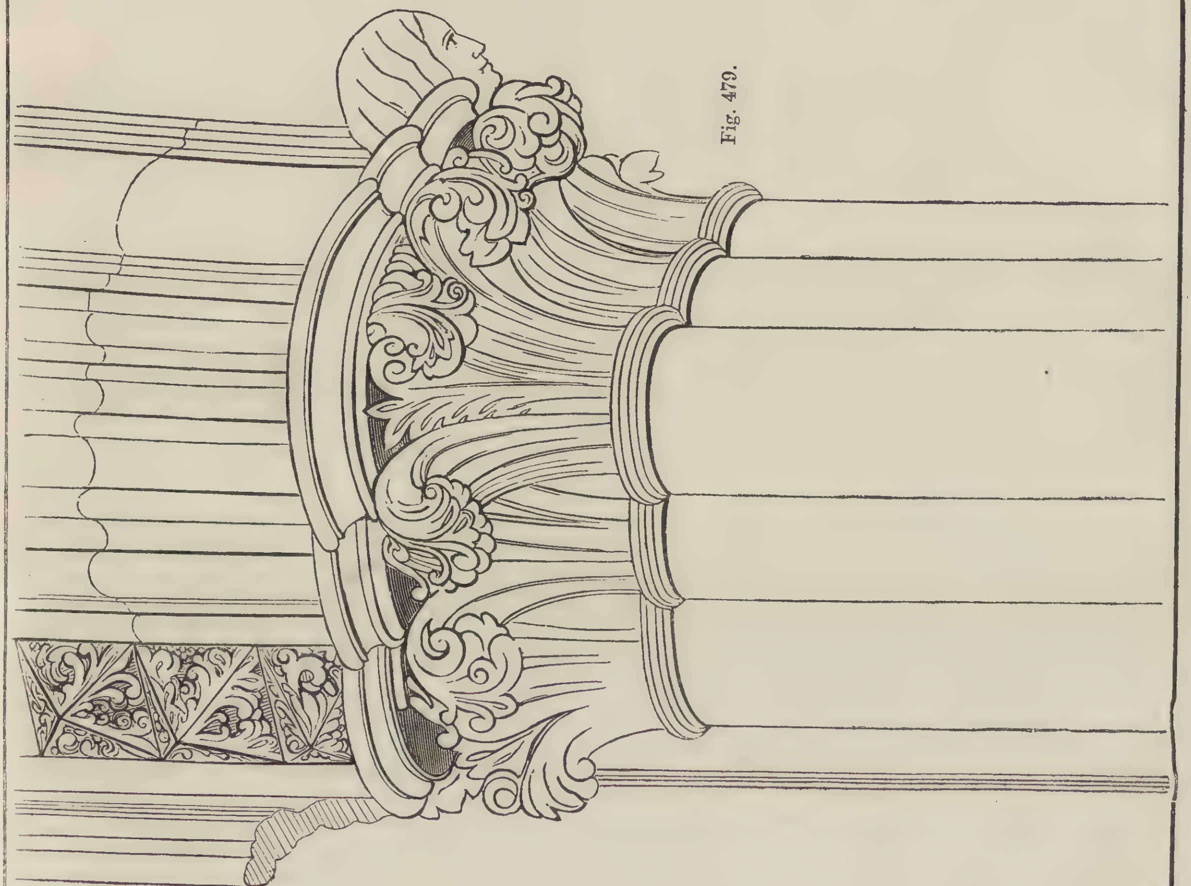


Fig. 479.

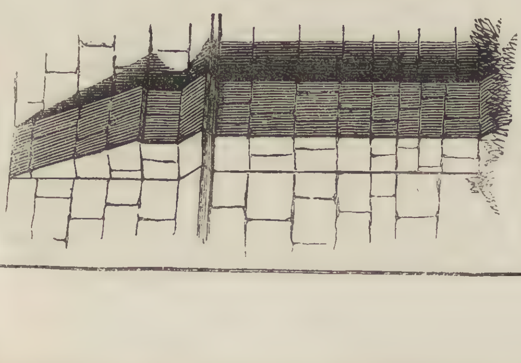


Fig. 480.

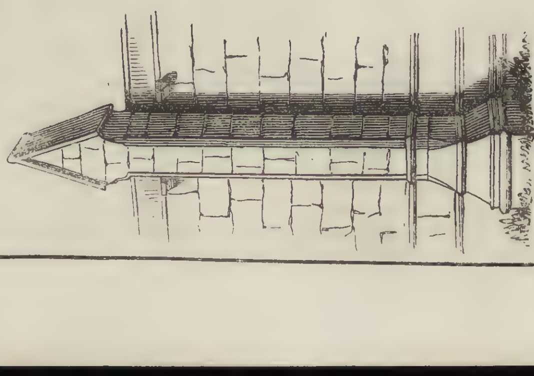


Fig. 481.

FISH CULTURE.—III.

By Greville Fennell.

EXPERIMENTS IN TASMANIA—LOVE OF FISH BY THE FRENCH—BREEDING FISH—METHOD OF EXTRACTING THE EGGS.

Considerable interest is attached to the results of the experiments in Tasmania. The first lot of ova, some 4,000 in number, sent out by Mr. Youll, were hatched in June, 1864, in the river Plenty, a tributary of the Derwent, about seventy miles from the sea; 300 trout (*Salmo trutta*) were hatched at the same time. Several parcels of trout eggs have been sent out since, but those first mentioned were the only ones amongst the number which proved a success, the happy result being attributable to the great care and admirable judgment displayed in their mode of transit by Mr. Youll, and by Messrs. Francis Francis and Frank Buckland in their selection. In June, 1866, from 8,000 to 10,000 salmon ova were hatched out, and about 8,000 salmon trout. Part of the latter, say 1,000, were kept in the breeding ponds on the Plenty to ascertain whether they would breed in fresh waters without going to the ocean. The remainder, with the salmon parr, were in 1868 given their liberty, the ponds being thrown open, and they went to sea.

It appears since that period, that among the supposed salmon trout, some few salmon parr were found to have been left in the ponds; and specimens of this fish, hatched, as we have said, from ova sent out from England, and thus kept in confinement, have been pronounced by Dr. Günther, to whom they were entrusted to be examined, to exhibit characteristics both of the true salmon and the salmon trout. The *produce* of these fish of different kinds bred in the ponds have also been forwarded to Dr. Günther, and have proved to be the true salmon, a fact which has never occurred in the history of pisciculture. These ponds on the river Plenty are admirably constructed; the water is exquisite in its character, gravelly scours or rills are here, there, and everywhere, and a clear sharp stream running continuously over them, and through the ponds; but there is no possibility of salt or even brackish water getting access to them, which renders the above-mentioned facts the more remarkable; indeed the sea, as mentioned, is seventy miles off, and its flow inland up the Derwent comparatively insignificant; the Plenty is, moreover, an affluent of this river far removed by distance and altitude from the influence of the ocean.

No true salmon have, however, yet been caught in the rivers of Tasmania, although at the end of 1870 a net was fixed in the Derwent near the mouth of the Plenty, and several fish weighing from 3 to 4½ lb. and one which weighed 7¼ lb. were taken. These fish were at first supposed to be true salmon, but upon a more careful examination they were found to be the salmon trout. The 7¼ lb. fish was presented to Governor Ducane, who pronounced it an admirable table fish in every respect. Thus the question forces itself upon us, that as the salmon trout undertook their errand to the sea and faithfully returned to their old quarters, how is it that, with the very same process and under similar conditions, none of the salmon proper have as yet put in an appearance? There are perhaps more than twenty creditable witnesses who were ready to declare that they could not be mistaken in having seen the salmon swim and leap in the Derwent, and some of these state that they have not only seen them once, but upon several occasions; let us hope they may be right. To prove the presence of fish in the Derwent is not the matter of ease it would be in any of the British streams, or even of those of most parts of the world. In the Derwent it is attended with immense difficulty, which none but those familiar with its waters can imagine. Sunken snags might be removed in time; but the tee-trees which grow upon its banks, send forth their roots under water in every direction to a great length, and present the most formidable obstacle to the working of a net and the safest possible stronghold for the fish. Then the fish are in a primeval state, unaccustomed to the sight of man, or the movement of a boat, and do not partake of that fatal confidence that some kinds of fowls do upon their first introduction to the human form. The fish are off at once, and defy the little art as yet possessed by the inhabitants for their capture.

Mr. Youll deserves every credit for the perseverance and skill he has brought to bear upon the introduction of fish of the *Salmo* tribe into Tasmania, which has been attended with great expense, and many vexatious disappointments. This gentleman's method of packing the ova is ingenious, and, simple as it may read, was the result of many careful experiments. The moss in which the ova are laid is not dead and rootless, but in full vigour of growth, a vitality which the flow from the ice boxes which accompany the eggs perpetuates throughout the whole voyage, and while the temperature is by this means kept down—more particularly in the tropics, where otherwise the eggs would hatch and be destroyed—the ova are preserved as fresh as if they had but just fallen from the parent fish. As, however, some few of the eggs will even in their natural bed become blind and decay, and thus without care prejudicially infect the remaining stock, Mr. Youll underlaid the moss with powdered charcoal, which, acting as a disinfectant, met any threatened difficulty from this cause. No leaden pipes engendering arsenical influences were used on this occasion, and the whole of this vital apparatus was so swung and placed in the space on board the ship devoted to it, as to prevent injurious oscillation and frictional contact. The ova from the fish bred in the Plenty have been safely sent in this manner to Victoria and New Zealand, and in the latter colony they have now many thousands of young trout.

Thus it will be seen that while salmon proper are still a novelty in Tasmania, trout are abundant. Indeed, the success of the trout, both as to their increase and the marvellous rapidity with which they have grown, is most remarkable. There are thousands upon thousands of trout now in the river Plenty and neighbouring waters. During the last spawning season we are assured that "the 'rids,' or nests of the eggs, of this fish extended for several miles, and beautiful fish have been observed engaged in their interesting duties from 3½ up to 12 lb.; and these, we may add with pride and thankfulness, are the fish, the original ova of which was sent to us in benevolent thoughtfulness by Messrs. Francis and Buckland, thus providing the nucleus for an enduring and ever-increasing supply of delicious and nutritious food for all within reach."

To the French people every kind of fish is acceptable as diet, from whatever waters they may be derived. In our own country the salmon and trout grayling are bred artificially as yet, and it is a great question whether the breeding of any other would yield a commercial profit, as fresh-water fish in general with us are much despised, although undeservedly so. We have known perch cost half-a-crown a pound; and there are epicures amongst our aristocracy who make it a practice always to have a pike upon the table. There is, however, no occasion to breed these fish artificially, as they would multiply in sufficient numbers to meet almost any demand, if properly protected. A pike, for instance—according to Mr. Buckland's crucial examination—weighing 32 lb. will produce 595,200 eggs, and a salmon of the same weight will contain about 29,000 eggs, so that it will be evident that a pike produces a much larger proportion of eggs than a salmon.

We might learn a profitable lesson here from the Jews, who are the best patrons of the fresh-water salesman. Barbel, thought by us to contain elements of blood poison, are boiled by the Jews in vinegar and water, and make a most acceptable dish. Dace, which scarcely one English cook out of a hundred can render palatable, a Hebrew *chef* will place upon the table with a *goût*, if not superior, equal to smelts; and roach, and every other fish discarded by us, are made to contribute a welcome and rapid addition to the domestic resources of the poor and wealthy of the thoughtful and industrious children of Israel.

Even the much-abused bream, that of the bronzed or golden kind, are highly esteemed in some parts of England. Indeed, at Gainsborough-on-Trent, there are fishermen who wholly subsist, and make a good living, by angling for this fish during those months in which it is supposed to be in its prime. Chaucer speaks of this bream in terms of eulogy. The belly and fins are the best parts, and are of a rich luscious flavour. Their cost in Gainsborough is about fourpence per pound, and they are much sought after, as, from being caught only by the rod, the supply is uncertain. In France the eel is bred in considerable numbers, and highly prized for the table. In Scotland and some parts of England they are viewed with a perfect loathing; and the keepers—strong and vigorous men—would rather face a wild cat than touch one. Yet so plentiful are eels in some Scotch rivers, that the angler can scarcely get his bait down before it is seized by one; but they are, from their countless numbers, of a very small size, six or eight to the pound being

considered large. It has often occurred to us that these eels might be transported to some of our ponds, where, by judicious management and feeding, they could be brought in weight and flavour to great perfection, and yield a handsome profit to the fish-farmer, as the English people in general, being very fond of eels, would be able to consume any quantity that might be offered for sale.

We are, therefore, glad to find that the attention we have called to this subject elsewhere has arrested the notice of Her Majesty's Inspectors of Fisheries in Scotland, Mr. Buckland giving the whole of Appendix No. XX. to its consideration. That gentleman says, "I was much surprised, during my inspection of salmon rivers in Scotland, not to find any apparatus at work for catching eels. I venture, therefore, to state, in my opinion, that the eel fisheries in Scotland should at once be worked. If this were done in a practical manner, I feel confident that a considerable revenue might be derived by individuals from eels, and the public at the same time benefited by an increased supply of good food now quite neglected. It cannot be otherwise, than that thousands of tons of eels *are allowed to escape* down into the sea during the autumn months from the rivers and lakes in Scotland. I have myself on several occasions found young elvers attempting to get over the dam dykes in various parts of Scotland; and a gentleman thoroughly conversant with Scotch fisheries writes me, 'Myriads of elvers ascend the Tay in spring and early summer, and, of course, must descend in autumn and winter, but they are not caught.' What goes on in the Tay doubtless also occurs in most if not all the chief rivers of Scotland. Why should all these tons of eels be lost to the public? I have heard of an eel fishery in Ireland which formerly let for £700 per annum; facilities were given the elvers to get over the dykes, and this fishery now lets for over £2,000 per annum. I am well aware that the Scotch people will not eat eels; they rather look upon them as food with abhorrence; but I imagine the Scotch proprietors of fisheries would not hesitate to sell the produce of their fisheries if they could find a market. The inhabitants of large English towns, such as London, Birmingham, Manchester, Liverpool, Leeds, etc., would have no scruples in taking any quantity of eels; and railway communication is so easy, that eels could be sent to the large English cities from the chief Scotch rivers with the greatest ease." It is to be remarked that the eels are going down when the salmon are coming up. Eel weirs can be set without mischief to the river from June to December; they should be entirely removed from December to June. I sincerely trust the utilisation of the eels in Scotland will not be lost sight of. As for the feasibility of a profit attending a supply, Messrs. Grant and May, the chief dealers in eels in Billingsgate Market, in reply to the question regarding the proposed transport of eels from Scotland to England write, "Eels are caught at some few places in Scotland and sent to market for sale. There is *always* a market here (Billingsgate) for eels."

The destruction of elvers or eel fry in our rivers, when they first appear from the sea admits of little excuse. In the Parret and other rivers which flow into the estuary of the Severn, the eel gala days find a parallel to what used to take place on the Thames' banks. All classes, either personally or by their agents, crowd down to the stream and strain the young fish out literally by thousands; and what for? to make an elver cake, which, for the appetite of a single farmer's boy, would take at least several hundred to satisfy every opening of his unappreciative jaws. Let the Scotch take the above observation to heart, or to the breeches pocket, and keep in view the fact that the owners of the Dutch eel *schuyts* have found it worth their while to cross the main and come to Billingsgate from the days of Queen Bess, and have generally amassed considerable wealth by the pursuit of this industry alone. The eel is always in request. It is the food of the poor man when small and of the rich when fat, and of weight; and, as has been said, "a dearth of eels was never known dead or alive if fresh."

The best plan to keep eels in the stews or ponds is to surround the water with that description of wire fencing that curls inwards, which, despite the wonderful acrobatic faculty which they can exercise by the assistance of their prehensile tails, they can not surmount. It may be here remarked that the power in the tail of the eel is something marvellous. By this they can escape out of a deep pail or jar with great facility, presuming that the depth of the utensil is but half an inch shallower than the length of the eel, for that half inch is enough to permit of the eel standing upon its head against the side of its prison, and crooking its tail over the edge like a finger, lifting itself up and out of captivity.

In this country, as we have said, there is little demand for the coarser kinds of fresh-water fish, excepting for the recreation of the rod. On the contrary, in Paris, a visit to the fish markets will show to what an extent the waters are utilised and the value placed upon all kinds of fish. In France, Germany, and elsewhere abroad, most of the fish for sale are kept alive in large troughs; and a housekeeper would as soon think of putting a fowl down to roast with the feathers on, as purchase a fish she had not seen swimming about and lively at the time she struck the bargain for its possession.

We learn from various authorities the method of extracting the eggs.

M. Gehin says:—"I take a female trout when she is ready to spawn, and—very much importance is, of course, attached to this fact—holding her by the back with my left hand, I prevent her violent efforts by pressing her head and body against it, and with my other hand stroke her belly, till in a few moments she becomes quieted." "All animals," adds an able writer, "are sensible to these caresses, or similar ones made on their backs, and take them willingly; witness the cat and dog, which by purring, whining, rubbing against us, or licking our hands, seek to obtain them." We scarcely subscribe to this, inasmuch as, to render the parallel complete, the cat or dog ought to be put under water, that is, out of their natural element, during this presumedly soothing and mollifying process. The stillness of the fish is more likely to arise from fright, combined with the sensation of smothering which it must necessarily undergo in an element it is not accustomed to. All the caresses bestowed even upon a freshly-caught bird, although in its natural element, do not tend to soothe or allay the rapid beatings of its fearful heart.

When the fish is thus magnetised or "put to sleep," as it has been facetiously termed, it is inclined over a utensil which has been prepared to receive the eggs by putting in it about a quart of water; in order to ensure the fish remaining quiet, another person, if necessary, holds its tail, then M. Gehin, with the thumb and fore-finger of his right hand, presses lightly the belly from top to bottom. This must be carefully and gently done, as one would press from root to extremity a finger cut at the end, to extract the blood and prevent its further flow; or as one would milk a cow, but by no means with so much force as that operation requires, for if the proper time has been chosen, the eggs will be pressed out by a very gentle effort, and if more is required, it will prove that the fish has not gone her full time for spawning, and the eggs thus obtained cannot in that case be fecundated.

Passing the finger and thumb in this manner over the fish's belly, the eggs at each pass will spirt out like the shot out of a shot belt.

When by a number of these passes the eggs are all pressed out, a male fish is taken and operated upon in the same manner; the milt thus expressed from the male, falling into the utensil and upon the eggs, gives the water a white hue. The male fish, like the female, must be subjected to a number of gentle passes to obtain the result. When this is done, the contents of the vase must be stirred about with the hand, or, what is better, with the tail of the male fish still wet with the milt that has run over it (or a feather), an operation resembling that made by the fish in its natural state.

After a very short period the water must be carefully poured off, and a like quantity of fresh water poured on the eggs.

Before the mixture of the milt and the water covering the trout's eggs the eggs are of a pale orange colour, and transparent. After this operation the water must be changed once or twice more.

When the fecundation is complete, some of the eggs will appear white. These are the unfecundated ones, being sterile and dead, and if allowed to remain, will, like all other lifeless things, become putrid, and corrupt the rest; they must, therefore, be carefully removed.

A representation of the method of holding the female trout for the extraction of the eggs has been already given in our first article on this important and interesting subject in page 353 of the second volume of The Technical Educator.

PRINCIPLES OF DESIGN.—XXVI.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

SILVERSMITHS' WORK.

CONTINUING our consideration of hollow vessels, we have now to notice silversmiths' work, and here we may observe that while the material with which we have now to deal differs in character widely from that of which those vessels already considered have been formed, yet that many principles which have been enunciated are equally applicable to the objects now under consideration. Silver objects, like those formed of clay or glass, should perfectly serve the end for which they have been formed; also, the fact that ornament applied to rounded surfaces should be adapted for being viewed in perspective remains as binding on us as before; but herein the works of the silversmith differ from those already considered—they are formed of a material of intrinsic value, which is not the case with articles of earthenware or glass. Silver and gold being materials of considerable worth, it is necessary that the utmost economy be observed in using them, and in order to effect this a special mode of construction must be resorted to. If we propose to ourselves the formation of a sugar-basin of semi-circular shape, of what thickness must the metal be in order that it may not bend when lifted? It is obvious that the vessel must not yield its shape to ordinary pressure, nor be subject to alterations of form when in ordinary use; but if it is to be formed throughout of metal of such thickness as will secure its retaining its shape, it will be costly and heavy, and an amount of metal will be used in its formation sufficient for the manufacture of two or three such articles.

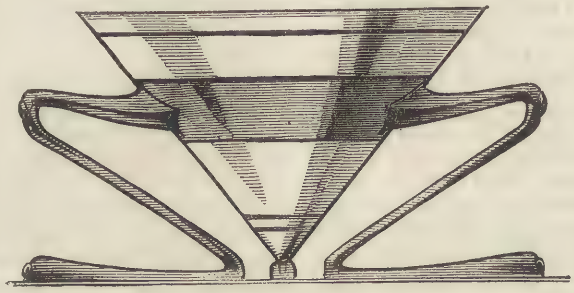
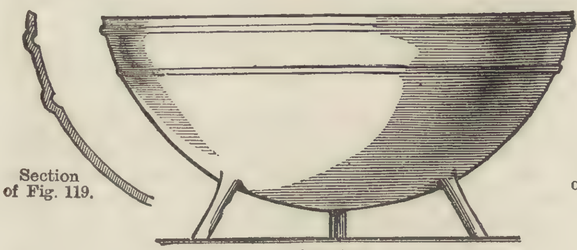


Fig. 122.



Section of Fig. 119.

Fig. 119.

Section of Fig. 120.

Fig. 120.

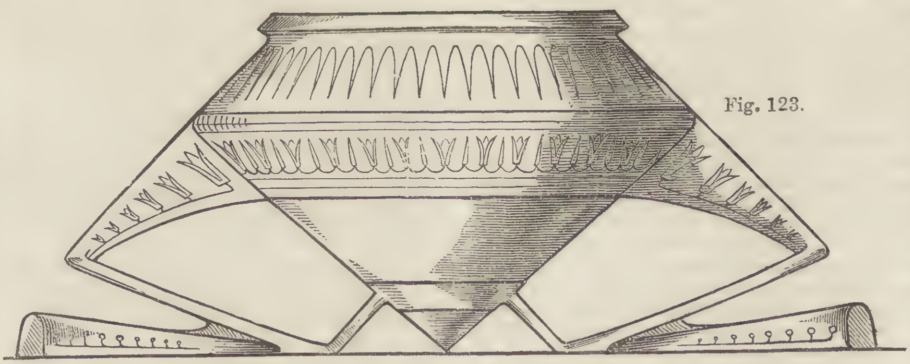


Fig. 123.

Instead of forming the vessel throughout of thick metal, we may construct it from a thin sheet of silver; but in order that it may possess sufficient strength we must indent one or more beads in its side (see Fig. 119); or we can form an angle by having a rim projecting into the basin (Fig. 120), or extending from it, and thus give strength; but the two beads are the more desirable, as the one gives strength at the top and the other at a lower portion of the vessel.

Modes of economising material, when we are forming vessels of costly substances, are of the utmost importance, and should be carefully thought out. If the designer forms works which are expensive, he places them beyond the reach of those who might otherwise enjoy them, and if heavy they appear clumsy in the hands of those accustomed to delicate and beautiful objects.

Besides this, works in silver and in gold are always in danger of being destroyed, owing to the intrinsic value of these metals; and if stolen, the theft is promptly hidden in the melting-pot. Now if we form the vessels of thin metal, we render the money value of the material less, and thus our works are to a smaller degree tempting to the avaricious, and their chance of longevity is greater. The precious metals are at all times perilous materials for the formation of works of art; but while we do use these worthy materials, let us so employ them as to give to our works every possible opportunity for long existence. If a work is to be so formed that it may exist for many years, it becomes of the highest importance that those objects which we create be well considered as to their utility, and at the same time beautiful in form. Long existence is an evil in the case of an ugly object, or an ill-considered vessel; that which is not refining in its influence is better blotted out. Let that man who will not seek to embody beauty in his works make them heavy with metal, so that they may tempt the thief, and thus sooner blot out his works, as they tend only to debase and degrade; but he who loves refinement, and seeks to give chasteness of character to the objects which he creates, may well strive to secure to them length of duration.

There are various modes of working metal. It may be cast, hammered, cut, engraved, and manipulated in various ways.

Little that is satisfactory can result from casting. Casting is a rough means of producing a result, and at best achieves the formation of a mass which may be less troublesome to cut into shape than a more solid piece of metal; but casting without the application of other means of working metal achieves little of an art nature.

Some of the fine iron castings of Berlin are wonderfully good in their way, and are to an extent artistic; and certainly they contrast strangely with the cast handles and knobs which we often

see applied to vegetable-dishes, and similar silver objects here in England; yet even these will not compare with works wrought by the hammer and the chisel. Thin metal hammered into form, and touched where necessary with the chisel, the graver, and the chasing-tool, is capable of producing the very finest effects which can be achieved in metal-work. Let the reader consider the beautiful vessels which Arabian metal-work presents us with: these are all formed by the hammer and chisel, with the assistance of the graver and chasing-tool, and how marvellously delicate and beautiful are the results! We have in these vessels beauty and dignity of form, richness of design, great intricacy and delicacy of detail, and altogether a refinement of effect which may long be considered and repeatedly enjoyed (Fig. 121).

Fig. 121.

Several, I may almost say many, of these beautiful objects are to be found in the South Kensington Museum, and it should be generally known that exact fac-similes of these lovely works, in the form of electrotype copies, have been prepared by Messrs. Elkington and Co., under the sanction of the authorities of the Department of Science and Art, and that these are procurable at small cost. For purposes of study these copies are of almost equal value with the originals, and for the adornment of a sideboard they are hardly inferior. I strongly advise those who can afford to purchase these beautiful copies to garnish their sideboards with plate of this description rather than with the meretricious electro-plate which we often see in our shop-windows.

Having determined on the best mode of working the material, consider carefully the requirements which the work to be produced is intended to meet, and then strive to form the object so that it may perfectly answer the end proposed by its creation.

Let us take a sugar-basin. What form should it have? After much consideration, I have arrived at the conclusion that the two shapes engraved in Figs. 122 and 123 are those which best fulfil the requirements of such a vessel, for in these the sugar is always collected together, and the dust sugar separates itself from the lumps.

The handles of a sugar-basin are often so small as to be partially or wholly useless. It not unfrequently happens that only one or two fingers can rest on the small handle, while the thumb has to be placed within the orifice of the basin when it is desired to move it. This should not be so; if a handle is to exist at all, it should be so formed as to be useful, and afford a means of moving the object with ease and comfort.

To form a handle as a mere ornament is an absurdity, for the handle is part of the vessel structurally, while the ornamentation is an after and separate consideration. In order to its existence a vessel must be constructed, but when formed it need not of necessity be ornamented; ornamentation must ever be regarded as separate from construction.

Such a sugar-basin as I have suggested would not stand without legs: it must therefore have them; but I see no reason why the legs and handles should not be combined; hence I propose three feet so formed as to serve as handles throughout their upper part (Figs. 122, 123), they being convenient to hold.

Modern European silversmiths have fallen into the error (an error now prevailing wherever art can be applied to any object) of making their works of a pictorial, rather than an ornamental character—an error which the Arabians, Indians, and Japanese never perpetrate, while their works in metal are unsurpassed by any others, and equalled by indeed few. It is a mistake to cover an entire vase with figures in high relief; but wherever anything of the kind is attempted, care must be exercised in causing the groups to follow the line of the vase, and not to appear as irregular projections from it. As to the modes of decorating works in silver and in gold, they are many; of ornamentation by *repoussé* work we have already spoken, and of chasing and engraving. But besides these there are other methods, and some of great interest, for there is damascene work, or inlaying, and applying colour, or enamelling, and niello work; jewels may also be added.

Damascene work is of great interest. Metal of one colour is inlaid into metal of another colour. India produces, perhaps, the rarest examples of this kind of work, the Indians being experts at this manufacture; but the Indian work consists chiefly of silver inlaid in iron. This mode of work seems to be capable of producing many beautiful effects, as all who have examined the large inlaid hookahs of India will admit.

CHEMISTRY APPLIED TO THE ARTS.—XV.

BY GEORGE GLADSTONE, F.C.S.

ACETIC ACID.

This acid is more familiarly known under the name of vinegar, of which it is the important principle. It is yielded at a certain stage of the fermentation of all sweet vegetable juices; but each of these imparts its own special characteristics, so that the vinegars of commerce are distinguished by the addition of the article from which it is derived, as malt vinegar, wine vinegar, etc. The mode of preparing the qualities in general use will have to be described presently.

The pure acid forms a crystalline solid at any ordinary temperature, having the chemical composition, $C_2H_4O_2$; but it combines with any quantity of water, forming a very pungent, colourless liquid. The absolute acid is usually obtained by distilling the acetates of sodium or potassium with sulphuric acid, stirring a little peroxide of lead into the product, and then re-distilling it. It can also be made by the direct oxidation of alcohol, C_2H_6O, when two atoms of the hydrogen are replaced by one of oxygen. The ordinary processes of the vinegar manufacture will be found to be mere modifications of this latter reaction. The commercial acid is now principally made by the distillation of wood, and hence it is generally known under the name of pyroligneous acid. It is largely used in making the various articles used for manufacturing purposes.

Vinegars seldom contain more than about 5 per cent. of the absolute acid; and their colour and flavour depend materially upon the ingredients from which they are made. In England they are usually made of malt; in France, of grapes; in Germany, of grapes, beetroot, or potatoes.

The ordinary plan is to make a decoction of ground malt in a mash tun, similar to what is used by brewers, 100 gallons of water being used for every six bushels of malt. It is important, in an economical point of view, to extract during the brewing the whole of the saccharine matter contained in the malt; and this is best done, not by putting in all the water at once, but by making two or three separate brews. The first should be heated to about 180° Fahrenheit, the others rather higher, or up to the boiling-point. Of course, the last yield will be much weaker, but they all pass into the same receptacle, and so become mixed together.

The wort thus produced is allowed to settle, and is then drawn off and left to cool; four gallons of yeast are then added, and well stirred in. After remaining about a day and a half, the liquor is transferred to the casks, in which it remains for about three months, by which time it is converted into vinegar. The casks are only partially filled, and have the bung-holes left open and a hole bored in each end near the upper edge, so that there shall be free access of air during the whole time; without this the acetic fermentation will not take place. In summer-time no artificial heat is required for this last operation: the casks are ranged in long tiers in the yard, without any other protection from the weather than a loose cover over the bung-hole during rain. In winter fielding cannot be attempted: the casks are then ranged in apartments which are maintained at a temperature of about 75° Fahrenheit.

The vinegar having thus been made, is drawn off from the casks, and put into the refining vessels to be clarified. These consist of tuns fitted with a double bottom, between which rapes (which are the refuse skins and stalks of grapes from the wine makers) are put, and through which the vinegar has to filter. A tap below the level of the false bottom allows the outflow of the vinegar, after filtration, into a cistern, from which it is pumped up again into the refining vat, to repeat the same operation. This is done several times, until the vinegar becomes quite clear and bright, when it is ready to be put into casks for the market.

There are two practical inconveniences in the process just described—the length of time required, and the large space occupied by the rows of casks. As the action is dependent upon the supply of air to the fermenting wort, it is evident that by increasing the surface of the liquor which is exposed to this oxidising influence, a larger quantity will become acetified in the same space of time. Various plans have therefore been suggested for the more rapid production of vinegar, all dependent upon this one idea. In one of these the liquor is made to pass through a large tun filled with beech-wood shavings, near the bottom of which holes are bored to admit the air, while in the lid are little pipes or chimneys for carrying off the waste gases. By this arrangement the liquid gradually trickles down, exposing an immense surface to the air, which at the same time is passing upwards through the vat, and the final result is accelerated in proportion. When a vat is fresh started, some hot, strong vinegar is passed through it for a day or two, in order to saturate the shavings and give them the character of mother liquor, which expedites the conversion of the rest. While the acetification is going on in the vat the temperature must be carefully watched with a thermometer, as the tendency of the operation is to generate heat, and if this proceeds too far, the spirit is driven off in the shape of aldehyde (C_2H_4O), which is a highly volatile substance, and a proportionate quantity of vinegar is lost.

Another adaptation of the same principle is to introduce the wort through a pipe which runs perpendicularly through the centre of the vat, the pipe being pierced with holes and made to revolve. The liquid is thus thrown in the form of a shower upon the shavings, and so presents a great extent of surface to the action of the air.

Vinegars are known in the trade by the numbers 18, 20, 22, 24, which represent respectively the number of grains of carbonate of sodium which will neutralise an ounce by measure of the liquid, and hence indicate the proportion of acid contained in the vinegar, No. 24 being equal to about 5 per cent. For domestic purposes No. 22 is preferable, as being sufficiently strong. It is highly valuable as a preservative from decomposition, on account of its coagulating the albuminous portions of animal matter, and more particularly of fish. It exercises the same function with respect to vegetable substances in converting them into pickles; and its liberal use is particularly to be desired on shipboard, and under any other circumstances where fresh meat and vegetables cannot be procured in sufficient quantity. Vinegar, however, being a product of fermentation, is itself, nevertheless, liable to putrefaction, the mothers consisting of an accumulation of a fungoid plant called *mycodenma vini*. The propagation of this plant, or of worms, in the vinegar, is often stopped by the addition of not exceeding 1 per cent. of sulphuric acid.

For manufacturing purposes the acetic acid made by the destructive distillation of wood is principally employed. On account of its origin, it is very commonly called "wood spirit." The plan adopted in its manufacture is a comparatively simple one. An iron cylinder or box forms the receptacle for the wood to be distilled, immediately underneath which is the furnace. From the upper part of the retort a pipe passes into the condensing chamber, where it is cooled by a stream of fresh water playing upon its outer surface, the condensed vapour pouring out into the receiver at the further end. The distillate, as it first comes over, consists of a mixture of water, acetic acid, naphtha, and tar, which are separated by re-distillation, the naphtha coming off at a lower temperature than the other ingredients, and the tar being the last to remain in the retort.

The quantity of acid produced varies according to the kind of timber used, within the limits of $6\frac{1}{2}$ to $7\frac{1}{2}$ ounces per pound of wood; but, when the distillation is over, there remains behind from $3\frac{1}{2}$ to $4\frac{1}{2}$ ounces of charcoal, which, in this country especially, where wood is dear, is an article of considerable value. In order to economise waste products, some manufacturers convert sawdust, spent tan and dyewoods, into pyroligneous acid, after they have fulfilled their more special uses.

In some works the acid vapour, as it passes from the carbonising cylinder, is brought at once into contact with one or other of the bases with which it has a strong affinity, so that it at once enters into combination and forms an acetate, which can either be used as such, or from which a very pure acid can easily be prepared.

When the acid has been made by the first-named process, it has to be still further freed from the oily and tarry matters which may yet remain more or less mixed with it. This is usually done by converting it into the acetate of calcium, by boiling it up with an excess of lime and water, so as to ensure the whole of the acid being taken up. The excess of lime is then allowed to settle, the solution is drawn off, and then evaporated down until the whole of the acetate of calcium crystallises out, which is then distilled with sulphuric acid.

Some of the preparations made from this acid, such as acetic

ether and aromatic vinegar, are used in pharmacy. The former is made by distilling the anhydrous acetate of sodium with a mixture of sulphuric acid and absolute alcohol, in the proportions of 28 per cent. of the former and 32 per cent. of the latter to 40 per cent. of the salt. The product is neutralised with bicarbonate of soda, then agitated with chloride of calcium until all the water mixed with it has been absorbed, and finally re-distilled.

But the most useful compounds are the acetates, which are largely employed in the arts. They have been already referred to in the former articles of this series, which treat of bleaching and calico printing, but their preparation and use deserve to be more fully considered.

Acetic acid combines with iron in two different proportions. The ferrous acetate, $FeC_2H_3O_2$, is commonly made by digesting scrap iron with the crude wood spirit at a temperature of 150° Fahrenheit, or by decomposing a solution of copperas (sulphate of iron) with acetate of calcium. This salt produces with madder a deep black dye. The ferric acetate, $Fe_23(C_2H_3O_2)$, formed by dissolving the sesquioxide in acetic acid, or by mixing solutions of the ferric sulphate and acetate of barium or lead, is also much used by dyers. With ferrocyanide of potassium the former of these salts produces a blue colour, and the latter a brown.

Acetate of lead is also employed by dyers and calico printers. It may be prepared in several ways. One plan is to expose sheet lead in a close chamber to the fumes of acetic acid, which causes the metal to corrode and be covered with a mixture of carbonate and acetate, which is then scraped off and dissolved in a slight excess of acetic acid. On evaporating down the solution the acetate of lead will crystallise out. Another plan is to dissolve litharge in acetic acid, and crystallise out the resulting salt.

The acetate of manganese is made by decomposing the sulphate of manganese with acetate of calcium or lead. It is also used in dyeing and calico printing for producing a brown colour by the action of chloride of calcium.

The tin salt is used in producing spirit colours. In preparing this, the protochloride of tin dissolved in water is mixed with acetate of lead.

Acetate of copper, more commonly known as verdigris, is a very useful preparation, not only to the calico printer, but also to the maker of painters' colours. A process of manufacture very largely adopted is similar to that above described for making the lead salt. Thin sheets of copper are submitted in a close chamber to the action of the acid, and from time to time the verdigris which has accumulated on their surface is scraped off. Another plan, more commonly adopted in France, is to substitute the skins and other refuse of the grapes from which the juice has been expressed for wine, instead of the acid itself. The sheets of copper, first dipped in a solution of verdigris, and the grape skins, are placed in casks in alternate layers, and are thus left to ferment for twelve to twenty days, by which time a thick coating of green crystals will appear over the surface of the metal. The acetate is then scraped off, and the plates are ready for a second operation. In addition to being used for the purpose of producing colour, it is employed as a resist paste in calico printing, when a white pattern is required upon a cloth which has to be dyed with indigo.

There is still another very important compound to be touched upon. The use of alum as a mordant has been spoken of under that head in Article X., and one of the most convenient modes of using it is in the condition of a sesquiacetate of alumina. It is made by dissolving alum in a solution of acetate of calcium, a sufficient quantity of the former being supplied to decompose thoroughly the lime salt.

CIVIL ENGINEERING.—XIII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS.

THESE most useful, and, indeed, indispensable adjuncts to harbours having a certain aspect and formation, are of two kinds—fixed and floating. Any work, whether natural or artificial, which serves to break the violence of the waves, or the set of a current, may be denominated a "breakwater." From the exposed positions they of necessity occupy, the greatest care must be exercised in their construction.

Breakwaters date from a very early period. Their importance for the protection of shipping was appreciated by the earliest settlers upon the coasts of the Mediterranean, who frequently fixed the site of their coast towns in localities sheltered from the prevailing winds by some natural island or rock, and in some cases producing an excellent and well-sheltered harbour by the construction of a mole resting upon some natural formation. This plan was adopted by Dinocrates, the engineer employed by Alexander the Great in the construction of the harbour of Alexandria. Taking advantage of the island of Pharos, which lay at some distance from the mainland, and opposite the site marked out for the city, Dinocrates united it with the mainland by an extensive causeway, or earthen wall. This grand terrace divided the bay into two harbours, which communicated with each other by means of two openings left for the passage of ships. To render the harbour approachable at all times, a lighthouse was built on a rock some distance from the eastern extremity of the island.

The method adopted by the Romans in the construction of some of their breakwaters was as follows:—In situations which the depth or calmness of the sea would admit of, two ranges of piles, secured firmly together with chains, were driven in the line of the proposed breakwater. The earth was then taken out from between the two ranges, and the bed levelled. Mortar, consisting of two parts of a peculiar earth, found near Cumæ, and one of lime—a compound which possesses the property of hardening under water—was then thrown into the space between the piles, together with a proportional quantity of stones, until it was entirely filled. This course was not, however, always practicable, because if the sea were violent the mortar ran the risk of being washed away before it became hardened. In this case they adopted a most ingenious contrivance for building blocks of concrete close to the position they would occupy when submerged, and allowing the action of the water to carry them, when hardened, into the position intended. The method adopted was to build a strong platform of hewn stone blocks immediately adjoining the sea. A portion of this platform was horizontal, whilst that part facing the sea inclined towards it. On the flanks of the inclined plane walls were built projecting 18 inches above its face, and upon this enclosed space sand was laid. On this sand they commenced building a concrete block, and as soon as it was hardened by exposure to the air, the enclosing walls were removed, when, the sea gaining access to the sand, washed it away, and, leaving the block unsupported on a horizontal plane, it slid down the slope into the water. This process—slow, though sure—was repeated until the work was advanced as far as desired.

The value in marine engineering of *hydraulic* mortar, as it is termed, by which is implied mortar which will harden under water, is exceedingly great. As we shall have frequent occasion to allude to its employment, it will be as well in this place to describe its composition and character. Hydraulic mortars are usually composed of silica and caustic lime, and their peculiar property of becoming hard under water may be attributed to their forming a hydrated silicate of lime. When clay and magnesia are added, silicates of greater consistency and strength are produced. The silica should be prepared by calcining it with an alkaline earth at a bright red heat, after which it will dissolve in acids, and form a gelatinous paste. If quartzose sand is mixed with lime in the ordinary way, it will *not* form hydraulic mortar; but if it be burnt with lime after being reduced to fine grains, it will form a suitable ingredient for the purpose. Limestone containing 10 per cent. of clay, when strongly burnt, forms good hydraulic mortar, but if it contain a higher proportion of clay it will not set unless it is well ground. The Romans made use of pozzuolana very largely in forming their hydraulic mortars. This substance is a species of sand found abundantly in the neighbourhood of Rome. The catacombs were probably formed by the extraction of this material. That found near Baiæ, when mixed with lime and rubble, will harden under water as well, if not better, than when exposed to the air. Indeed, it appears that mortar so constituted becomes light and dry when exposed to a dry heat; but, when moisture supervenes, the particles cohere in such a manner that no action of water can disunite them. Limes, when mixed with sand or grains of silex to form ordinary mortar, being very soluble in water, remain in a soft state when excluded from the air for a length of time; but when a small portion of pozzuolana is added

in a finely-divided state, the lime loses its solubility, and in a short time hardens under water. This is most probably caused by a chemical combination taking place between the lime and the pozzuolana. The Romans formed hydraulic mortar also by combining pure lime with large proportions of pounded brick. They employed mortar of this description to line their reservoirs, and such mortars often exhibit a coating of carbonate of lime on their surface, but the mortar itself is extremely hard. Smeaton employed, in the erection of the Eddystone lighthouse, a mortar consisting of equal measures of Aberthaw lime, in the state of hydrate, and of finely-powdered pozzuolana. The quality of the limestone employed in the formation of hydraulic lime is of the utmost importance; that which contains clay, magnesia, iron, or manganese, in the proportion of not more than from 15 to 18 parts in 100 of the whole, is suitable. Mortar formed from such lime will set after six or seven days' immersion, and will continue to acquire hardness. Mortar formed with lime obtained from limestone which has, in addition, a greater amount of silica, will set on the second or third day after immersion, and in a month will become hard and perfectly insoluble. Lime is said to "set" when it will bear, without depression, a rod one-twentieth of an inch in diameter, loaded with a weight of 10 ounces avoirdupois. From the foregoing, it may be stated as a well-ascertained fact that no good hydraulic mortar can be made without silica. The action of heat upon limestone is to drive off the carbonic acid and water. If limestone is pure it will bear a white heat; but if it contains the properties necessary to render it a good hydraulic lime, it easily fuses; its calcination, therefore, requires more care. The heat should never exceed redness, and the burning should not proceed too rapidly. If exposed to too great a heat it becomes vitrified on the surface, and the carbonic acid is not driven off; consequently it will not slack. Hydraulic lime is now artificially prepared by mixing a certain proportion of alumina or clay with a "rich" lime, and then calcining it. By a *rich* lime is implied a lime that doubles its volume in slaking, and retains its consistency after being immersed for a length of time, and which will *entirely* dissolve in pure water. Such a lime will absorb nearly three times its weight of water in slaking. A *poor* lime, on the contrary, does not much augment its volume, and will only partially dissolve, absorbing not more than about 200 per cent. of water. With hydraulic lime artificially prepared, as above stated, a mass composed of hydraulic lime and rubble is made, called *béton*, the lime being slaked previous to its mixture. This *béton* sets well under water, and is very generally employed in France, where the piers of bridges and other submarine works are founded upon it, the *béton* being composed of sand, flint, and artificial hydraulic lime. The proportion of lime and clay for the manufacture of hydraulic lime must vary according to their quality; as a rule, 20 parts of dry clay added to 80 parts of rich unslaked lime, or to 140 parts of carbonate of lime, is found to be a good proportion; the finest and softest clays are always preferred. Hydraulic cement can be made containing 34 parts of clay, and 62 of carbonate of lime; and a lime obtained at Harwich, which sets very quickly, has 47 parts of clay, and 49 of carbonate of lime. Parker's cement, patented in 1796, is formed from a limestone found in beds of clay. It exists as nodules, which are called *septaria*, and contains 55 parts of lime, 38 of alumina, and 7 of oxide of iron. Smeaton considered *minion*, or siftings of the ironstone after calcination at the iron furnaces and ground in a mill, equivalent to as much pozzuolana, and he employed this minion in making hydraulic mortar.

The pozzuolana we have alluded to is composed of silica and alumina, varying in their proportions according to the locality it is taken from. That obtained near Naples is of volcanic origin, and when carefully analysed has been found to contain:

Silica	44·5	Oxide of iron	12·0
Alumina	15·0	Soda	4·0
Lime	8·8	Potash	1·4
Magnesia	4·7	Water	9·2

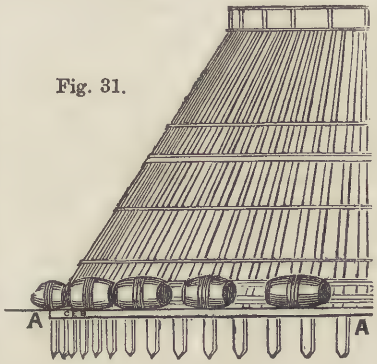


Fig. 31.

We have dwelt somewhat lengthily upon the character and qualifications of hydraulic mortar, because it occupies so highly an important position in all matters connected with submarine engineering, and because too much care cannot be bestowed upon its formation. We now return to our more immediate subject.

An *open* mole, or breakwater, was occasionally adopted by the Romans, and it undoubtedly has its advantages in some situations. It consists of a line of very strongly-constructed arches, and the remains, which still exist, of some of these open moles at Pozzuoli and Misenum show that the span of the arches was made equal to their depth, whilst the piers were half as wide again as the apertures. From the great depth of water in which some of the piers stand, there can be no doubt but that coffer-dams were employed in their construction. These coffer-dams might have consisted of a large galley having its sides considerably raised, and sunk to the bottom by weighty ballast, when, by heaping clay around the sunken craft, the bottom might be removed, and the foundations of the pier laid. These open breakwaters had considerable advantages in breaking the force of the waves, without hindering the flow of the water, so that no risk was run of the enclosed harbour becoming silted up. The mole at Misenum consists of a *double* open mole, the two lines of arches being so arranged as that the piers of one row stand immediately facing the openings of the other; thus a still greater barrier existed to break the force of the waves, and no risk of silting up existed.

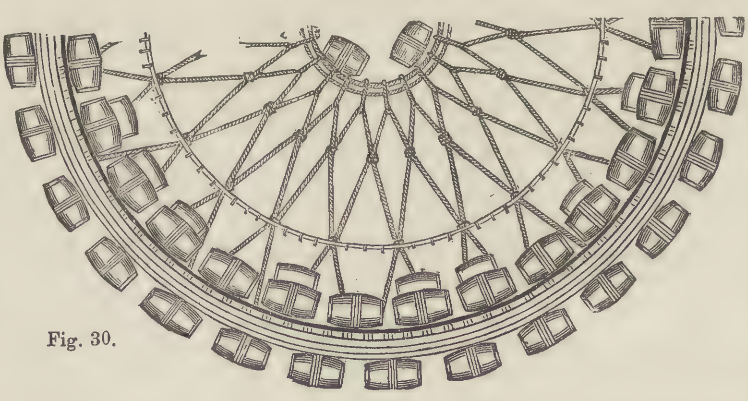


Fig. 30.

We shall now have to direct attention to the celebrated breakwater opposite the port of Cherbourg, commenced in 1783 by Louis Alexander de Cessart. It was necessary, owing to the depth and violence of the sea at the locality fixed upon for this structure, that some portions of it should be carried up to the height of 80 feet. To obviate the difficulty of building a solid mole, Cessart suggested the use of large truncated wooden cones, loaded with stone, and placed in a line at a distance of $1\frac{1}{2}$ miles from the shore. These cones were prepared on land, and floated to their destined position. All above the level of low water, after they were sunk, was to be filled up with masonry, faced with granite, and laid in pozzuolana.

The method of constructing the cones was as follows:—A circle of 150 feet diameter was traced out upon a platform previously laid down on the shore. Around this were set up 90 timbers, at a distance of about 5 feet 3 inches from centre to centre, and so inclined towards the centre that at the top they were gathered into a circle of about 64 feet diameter; the perpendicular height of the cone was nearly 70 feet. Each of the inclined timbers consisted alternately of five and six pieces.

The scantling of the timbers at bottom was about 13 inches square, and gradually diminished to 8 inches square at the top. The respective pieces were joined by a dovetailed scarf, 18 inches in length, the two ends of the scarf being secured by iron bolts and nuts. The inclined timbers were bound together by parallel horizontal rows or rings of timber, six rows on the outside, and twenty-four in the inside. These timbers consisted of oak and beech, and had a scantling of 13 inches square.

In order to float these immense timber structures, Cessart had recourse to casks, which he preferred to vessels, as being more under the control of the engineer, and more easily detached. The casks employed were 12 feet long, and 7 feet in diameter, and had each a power of flotation equal to about 28,000 lb. The entire cone, when completed, was calculated to weigh two millions of pounds, and, to ensure buoyancy, 35 casks were attached to the inside of the base of the cone, and 49 to the outside, whilst 31 smaller casks were placed inside. These casks were fastened by ropes to the structure, at regular intervals, all round, and in order to secure simultaneous action in the removal of the casks when the structure was floated over its proper position, loaded knives, similar to the guillotine, were suspended over each rope which held a cask; these being suspended from the upper part of the cone by ropes, could at any moment be let fall, when the released cask would come away.

Cessart arranged that certain casks at diametrically opposite points of the cone should be released at the same moment, and, upon a given signal, the cone being floated over its proper position, twenty-two of the casks were released, when immediately the cone sank 18 feet. Thus, by degrees, was each cone settled down upon its bed. The number of cones sunk was eighteen, and these were placed at irregular intervals, the extreme length occupied by their line being 12,470 feet, measured from the centre of the two extremes. After the cones were placed they were loaded with stone, and a great quantity was thrown in around their bases, and between their several intervals, for the purpose of breaking the force of the sea, the amount of stone deposited exceeding in the total 100 millions of cubic feet. This breakwater cost altogether upwards of £900,000. The timber of the cones soon went to decay from neglect, and the stones they contained fell into a natural slope with those around them. We subjoin two illustrations of this truly bold and original undertaking. Fig. 30 shows a portion of plan of the cone, with the casks attached around the base, and the interwoven ropes tending to the centre of the cone, in order to prevent the structure from spreading out. Fig. 31 represents an elevation of the cone, the sloping timbers resting at their foot upon a circular framing at A, and leaning towards a centre at the top. Vertical pieces sharpened as piles were fixed at the base, in order to take hold of the ground when sunk.

A breakwater of an important character, owing to its great usefulness, was erected at the mouth of the harbour at Aberdeen by Telford. . This work was commenced in 1808. So far back as 1769 it was contemplated to improve the harbour. The north-easterly winds, which frequently blow with great violence on this coast, were found to drive large deposits of sand, gravel, and shingle, which accumulated outside the mouth of the Dee, into the main channel, and choked it up. Smeaton was the first engineer whose assistance was sought for to remedy the evil. The position of the harbour's mouth is peculiar. The river Dee finds its way into the German Ocean immediately to the north of a projecting head of land, stretching for nearly a mile due east. This head receives the full force of a north and north-east wind, there being no counter-projection for many miles to the north. The result is that the set of the tide carries with it the sand, which forms the chief characteristic of this coast, and deposits it at the mouth of the river, which, except when there is an abundance of land-water, cannot force its way through the accumulation at ebb-tide. Smeaton, guided by his observations of this circumstance, recommended the erection of the north pier to serve the double purpose of a breakwater, and also to confine the land freshets till they arrived at the deep water, and to prevent the sand and gravel from being driven in.

He designed this pier in three sections. The first, resting upon the land, and not subject to the effects of the sea, was 400 feet long, 20 feet broad at the base, 12 feet at the top, and 12 feet high. The second section was also 400 feet long, but the base was extended to 28 feet, the top to 14·5 feet, and the height 20 feet. The third section extended 546 feet further, and had a mean breadth of 36 feet at the base, and 24 feet at the top. The mean thickness of the sides was 4·5 feet, and the space between was filled in with rough stones. The parapet was 4·5 feet thick at the base, and 3 feet at the top, and was 4 feet high. The cost of this pier was £10,000. It was completed in 1778. The effect of the pier was what had been anticipated, so far as freeing the passage was concerned, but it also had the effect of permitting the full force of the unbroken waves to enter the harbour and to expend themselves upon anything therein.

This was too serious an evil to remain. Smeaton therefore suggested that from the south side of the mouth formed by the north pier, a catch-pier or breakwater should be formed by the deposit of rough granite stones, projecting towards the middle of the open space, and inclining within the harbour. This, he thought, would catch the swell of the waves, and throw them away from the harbour upon the headland already alluded to; leaving at the same time a clear passage of 300 feet for vessels entering the harbour.

This catch-pier was formed of blocks of split granite, this work being done at the quarries. They were cut into wedge-shaped pieces, and made of parallel faces, each alternate stone composing the circular end of the pier being a header, the others tending towards the centre. The header stones were firmly secured by their small and inside ends to a cross stone by means of an iron cramp; these being secured, the reversed stones could not, of course, move. The iron cramps which secured the header-stones were an inch square, turned down at their ends, and fitted into holes "jumped" in the stone, not leaded, but retained by wooden wedges, as the weight of the courses above was sufficient to keep them in their places.

GREAT MANUFACTURES OF LITTLE THINGS.—IV.

PINS.

BY CHARLES HIBBS.

THE visitor to a modern pin factory, who sees before him a row of very noisy and excited little machines, each taking in wire at one extremity, and delivering perfect pins at the other, in a continual stream, without more attention than is involved in presenting a new coil of wire to be swallowed when the former one is run out, will be struck by the contrast between the pin manufacture of to-day, and that described by Adam Smith, a century ago. That great economist, it is familiarly known, chose the making of a pin as the aptest illustration of the advantages of division of labour. "One man draws out the wire; another straights it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head; to make the head, requires two or three distinct operations; to put it on is a peculiar business; to whiten the pins is another; it is even a trade by itself to put them in the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them." In this way, argued the author of the "Wealth of Nations," a man was enabled to produce some thousands of pins in a day, whereas, without division of labour, he could scarce, perhaps, make one, and certainly not twenty. Each of the machines now in use will turn out 300 perfect pins in a minute, and one man, with the assistance of one or two boys, can attend to ten or twelve machines. The statistics of this industry contradict the usual economic theory, that the introduction of machinery benefits the labourer by increasing the demand for his services. As the result of a somewhat painstaking inquiry, the following may be taken as an approximate estimate of the numbers employed in the best days of the old system of hand manufacture:—Skilled handicraftsmen, stamp-setters, pointers, drawers, head-cutters, whiteners, etc., 320; women and children, employed in heading and sticking, 3,900; in all, 4,220. In addition to these, pin-heading found an occupation for a large number of youthful criminals and paupers in our gaols and workhouses. At the present time the total numbers employed would certainly not reach 1,000, although the production of pins has, perhaps, multiplied sevenfold.. The earnings of the men are also much

smaller than in the old times. A pin-pointer of ordinary skill could earn on an average £3 per week; a drawer or head-cutter could make nearly as much; while a stamp-setter, who was, properly speaking, a sort of sub-contractor, employing women and children, and making a profit out of their labour, could realise from £5 to £10 per week. Few men now earn more than from 30s. to 40s. at any branch of the trade. The women employed in the modern manufacture certainly earn more than double the wages formerly paid, but then their numbers are but as 1 to 40. Neither does it appear that the manufacturer has been much of a gainer, the profits on the business, consequent on the introduction of machinery, bearing no sort of comparison with those realised in the cotton trade under similar circumstances. The chief portion of the benefit has, no doubt, gone to the public, in the shape of a greatly enhanced cheapness of the article; though it may be doubted whether the national wealth is much increased by the bushels of pins that must be swept away into dustholes every morning, after having been carelessly thrown away. Of the twenty-five tons of pins produced on an average every week, it is probable that at least twenty tons are absolutely wasted.

The pin itself being universally accepted as the very emblem of insignificance, not much is to be said regarding it. But the various stages in the history of its manufacture, with their accompanying vicissitudes, will be found replete with interest to the mechanical student and the economical inquirer, as illustrating the great ingenuity displayed in, and the important interests connected with "Great Manufactures of Little Things."

The metal pin, as an article of convenience or adornment, is of very remote antiquity. Isaiah, in inveighing against the frippery of the daughters of Zion, speaks of their crisping pins. Hair pins are referred to by Martial and by Juvenal as having been worn by the Roman ladies. Strutt, in his erudite work on the costumes of the English, makes mention of hair needles or bodkins as being used by the Saxons in the eighth century. It is nearly a matter of certainty that the making of pins, as a trade, found its way here from France in the reign of Queen Elizabeth, and that the first home of the manufacture was in Gloucester. So late as 1840, Gloucester continued to be one of the principal seats of this trade; nor was it until 1854 that it finally deserted that cathedral city for Birmingham, which now enjoys almost a monopoly of it.

It is proposed to take the reader through a manufactory of the old style, and explain to him the processes, which, though now out of date, will assist him in comprehending the difficulties surmounted, by slow and gradual degrees, in substituting for the skill of human fingers the automatic labour of machines of iron and steel. The successive mechanical inventions introduced into the trade with that object will be described in our next paper.

An important part of the old process was that of drawing the wire. Mill wire was not then delivered in a state of such high finish as at present, and the pinmaker had to perfect it before he could proceed. It is scarcely necessary to describe the operation. It consists in dragging the wire through tapering holes in a steel block, each successive hole being smaller than the last, thus bringing the wire gradually down to gauge, and lengthening it out. The wire being wound on to a drum or cylinder as it was drawn, was made up into bundles of a circular shape; and these bundles being delivered to the pinmakers, their first care, on unwinding them, was to straighten the wire preparatory to cutting it off in lengths. The method of doing this was apparently simple. The coil of wire was slipped on to a reel of conical shape, revolving easily round a pivot. The end of the wire was conducted to a block of wood, in which were stuck a series of pegs, arranged in a zigzag fashion, and the wire being threaded so as to pass on the outside of each, and afterwards between two rows of others set in line to act as guides, on being pulled through with a pair of pincers, came out perfectly straight. We have said *apparently* simple, because a great amount of skill and practice was required in setting the pegs, and their position had to be varied according to the thickness or hardness of the wire. A long shallow trough extended from the straightening block, and the workman pulled out the wires to the length of this, and then cut them off, the trough serving the double purpose of a length gauge and a receptacle. The wires were then cut into lengths sufficient for six pins, and in that state pointed at both ends. The pointer sat before a spindle, carrying two circular files (one rough and the other smooth, and about the size of the little grindstones which form part of the apparatus of an itinerant razor-grinder) round at the rate of about 7,000 revolutions a minute. Taking a number of the wires between the thumb and fore-finger of his left hand, he rolled them backwards and forwards, while the thumb of the right hand pressed their nibs upon the file. Two turns upon each of the files were sufficient to make a clean and sharp point. A clever pointer could take up fifty wires at a time, and make 500 points in a minute. A pin's length was then cut off from each end of the wire, after which it was again pointed at both ends, again cut off, and again pointed, this time being cut through the middle.

The head of an old-fashioned pin consisted of a turn or two of very fine wire wrapped round the blunt end, forming a sort of knot. We may remember how it used sometimes to slip down the shaft, like the time-ball in the Strand. In order to form the heads, this wire was wound upon another wire of the same gauge as the pin, closely and evenly from end to end, about forty feet. Being then slipped off, it was chopped up into little coils of two or two and a-half turns by a sort of guillotine. The method of threading on the pins was primitive. A little boy put two or three handfuls of the heads into his apron, and taking half a dozen or so of pins in his fingers, worked them about in the heap until they threaded themselves by accident. The heads were afterwards riveted on by another operator by means of a little die, and a punch worked with a treadle.

The pins were whitened by means of boiling them in water with grains of metallic tin and a certain quantity of bitartrate of potash. The only remaining process was to stick them in the paper, of which the old-fashioned method was as follows:—The paper being rapidly doubled, after having been previously crimpled by a machine, was pinched between the jaws of a vice, just sufficient of the two folds being left protruding. The top of the vice was nicked transversely, to correspond with the two half rows of pins, and the girl having a heap of pins before her, raked up a few of them with a comb, thus getting the heads all one way. Laying these on the top of the vice, she rubbed them about until one lay in each of the nicks, when, brushing off the remaining ones, she gave a push with the back of the comb against the heads, and every pin entered the paper in its proper place.

PAPER AND CARDBOARD MAKING.—IV.

BY GEORGE TINDALL.

PAPER-MAKING BY MACHINE.

The process of paper-making is now divided into two totally distinct methods—that by hand, the old process; and the comparatively new and much more rapid process by means of the paper-machine, although the process of preparing pulp is the same for both methods of making. Paper made by hand is now almost entirely confined to strong and tough writing-papers for account-books, drawing-papers, bank-notes, loan-papers, etc. These papers being dried in sheets suspended on cords, shrink considerably while passing through this process, and thus acquire a tenacity unattainable in papers finished at machine, where the paper is dried on heated cylinders as soon as it is made, and in a continuous web; but by cutting the sheet, and afterwards sizing and drying in the same way as hand-mades, machine-made papers are made to approach them very nearly in many of their most valued qualities, and bid fair shortly to entirely supersede the older process.

The various materials being now judiciously mixed, coloured, and reduced to the finest possible fibres by the processes already described, and which may be considered as preparatory, these fibres are now to be converted into one continuous sheet of uniform thickness, and with as much strength and tenacity as can be given to it. Although the greater part of the paper made by machine is termed "wove," yet the method of making bears no analogy to the process of weaving by which woollen and cotton fabrics are made, in which the fibres are warped together into a continuous thread or yarn, and these threads are made to cross each other by a process similar to the darning of a stocking, and a continuous cloth is the result; the paper-cloth is made by the natural interweaving of the fibres as they settle together in the process of manufacture. Theoretically, if

we place a quantity of paper-pulp with water in a flat tray or trough, the delicate fibres floating in the water will gradually fall to the bottom, interlacing each other in their descent, and forming a film or coating at the bottom of the trough; and if the water be drawn off without disturbing the film, or evaporated, and the film dried, a sheet of paper is the result; and practically this is what is done in paper-making, means being taken by machinery to remove the water and dry the paper as quickly as possible, and also to impart to it other necessary qualities not possessed by the simple film above mentioned.

Paper-making by hand, though still carried on in this country for the strongest descriptions of paper, is so far surpassed by the paper-making machine, that we shall describe the latter process first, referring to the former in our next article.

The diagram of the paper-making machine in the next page will enable us more readily to describe the various processes. It is drawn as simply as possible; the driving-gear, frame-work, and many of the bearings, being purposely omitted to show more distinctly the parts required for description.

The pulp being brought from the beating engines into the two large stuff-chests, A, is kept constantly agitated by means of a spindle furnished with cross-bars of wood, and driven by a bevel wheel over the centre of the chest. It is then raised by means of a pump into the small chest, from whence it flows into the mixing box, C; the quantity admitted being regulated by a tap. Three pipes open into this box, one conveying the prepared pulp, one bringing the back-water, as it is termed, from the machine—that is, the water drained away from the pulp, carrying with it some of the materials which are thus brought back to be used over again—and also a fresh-water pipe. In this box the pulp is mixed with the back-water, and, if necessary, with a quantity of fresh water also; and so mixed, flows over into a long wooden trough, D, called the "sand-catcher," from its having at short intervals along its course wooden projections from the bottom, in order to catch and retain the sand and heavier impurities which fall to the bottom by gravitation during the course of the fluid. It will have been noticed that in every process of preparation some means have been taken to separate and reject the dirt and other foreign matters necessarily mixed with the various materials used. This is of great importance, especially for fine papers, and too much care cannot be taken at every step; hitherto, however, the pulp has not been passed through a sieve, but this must be done before it is allowed to flow on to the machine. For this purpose it runs from the sand-catcher by means of the lips marked E into the trough, F, the bottom of which consists of brass plates cut with very fine slits called strainer-plates; the slits vary in breadth according to the quality of paper to be made, but for printings and writings they are very fine; and these strainers being kept constantly vibrating by means of a stud working on a ratchet-wheel, the clean pulp is passed through into a vat in which the strainers are placed, leaving the residue to be raked off and carried away.

From the strainers the pulp flows in a broad stream on to the machine. It is received on an endless wire web, G, kept travelling over a series of rollers, and here the process of extracting the water at once commences. This portion of the machine is agitated from side to side by means of suitable machinery, and by this shaking motion the pulp is evenly distributed over the wire, and forms as it were a deposit upon it, a portion of the water passing through the interstices of the wire, the rollers underneath assisting in the withdrawal of the water. At H the wire passes over two broad boxes called suction-boxes, and here means are taken to draw a considerable portion of the water out of the pulp, by creating a vacuum in these boxes underneath the wire; this is done in various ways, the usual and oldest method being by means of a set of three air-pumps placed behind the machine, a continuous partial vacuum being kept up by the alternate action of the three pumps. For many papers, however, the vacuum caused by the fall of a column of water through a pipe communicating with these boxes, and passing down under the machine, is sufficient, the pipe being bent upwards again at the bottom to prevent the air from passing up into the boxes. A more effectual method is by injecting a jet of steam into this pipe, thus forcibly expelling the water quickly, and forming a more powerful vacuum. Loose ends are fixed into the boxes worked by means of a screw, and these are brought up to the edge of the mass of pulp flowing along the wire, and thus the air is prevented from entering the boxes through the wire, and only the portion covered with pulp is acted upon.

From the head of the machine to the first of these suction-boxes, the pulp has been in quite a fluid condition, and is prevented from spreading and running off the edges of the wire by means of a continuous india-rubber band about one inch square called a "deckle strap:" this is pressed lightly on to the wire by means of a brass frame-work, and it returns over pulleys as shown at J, motion being given to it by the wire so that they travel together. Between the two suction-boxes is placed the dandy-roll, K, and here the film having been formed on the wire, and sufficient water having been drawn out of it to leave it a firm mass, is begun to be manipulated; the dandy-roll presses lightly on the film as it passes underneath it, and revolving in union with the wire in the same way as the deckle-strap, it forms the upper surface of the sheet, the machine wire forming the lower one; it is also used to impress in the paper any letters or device called the water-mark, as any impression here given to the sheet is retained through the subsequent processes and appears afterwards in the finished paper. If a wove paper is required, the dandy-roll is covered with woven wire, same as the machine wire, and a paper uniform on both sides is the result; if a laid paper is being made, the dandy is made of longitudinal wires crossed with transverse ones about an inch apart; these wires press into the surface of the pulp, forming the well-known laid mark, the lower surface being the same as the wove paper. Letters and other designs are made of fine wire attached to the dandy-roll, and these designs, as they are impressed into the yielding pulp, become permanently fixed in the sheet of paper so formed, and cannot afterwards be erased without destroying the sheet. The wire with the sheet of pulp thus formed next passes over the second vacuum-box, where it is still further exhausted of water, the action here being considerably stronger than in the first, and then passes between a pair of large cylinders called "couch rolls," L, covered with closely woven woollen felt, where a considerable pressure is employed, to compact the pulp together into a close thin sheet, and squeeze out the remaining water. The felt on the upper roll is kept thoroughly saturated by a continuous stream of water flowing over the top of it, and kept from running off by a board pressed closely to the felt, and this prevents the paper, now completely formed, from adhering to the rolls, so that it still follows the course of the wire; but it is now sufficiently strong to be handled, and the wire being carried round the lower couch roll and returned to the head of the machine, the sheet is detached from it and carried on to a felt travelling round a wooden roll in front of the couch roll and a very short distance from it. The sheet is now called water-leaf, and resembles a sheet of blotting-paper saturated with water. The felt, M, now carries it between a pair of metal rollers, the upper one being very smooth and well finished, and here it is subjected to considerable pressure, and the side next the roll is rendered much smoother and finer, and from this roll it is carried to another felt passing between another pair of press-rolls, where the opposite side of the sheet is next the smooth surface of the roll, and thus both sides receive the same treatment.

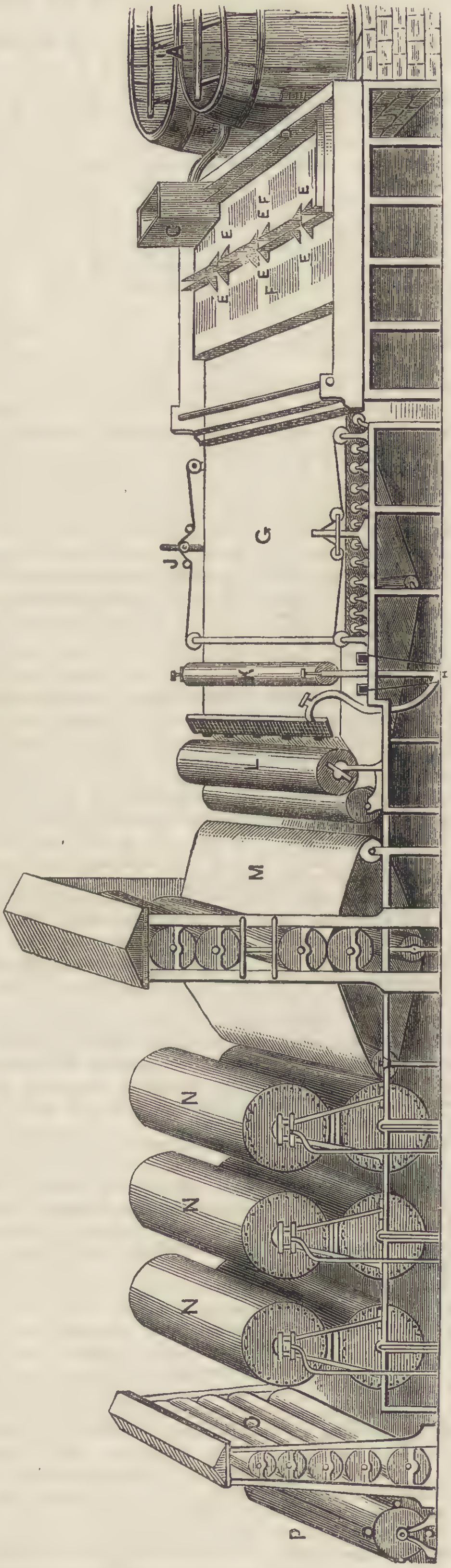
The sheet of paper, if made from engine-sized pulp, and if great tenacity is not requisite, is now practically made, and it only requires to be dried and the surface made sufficiently smooth by calendering, to be ready for cutting and packing for sale. The drying is performed by passing the sheet over a series of metal cylinders, N, heated by steam introduced into one axis of the cylinder, and passing out at the other: small rollers of wood or metal placed near the cylinders conduct the paper, and cause it to cover as much of the surface of the heated cylinders as possible; and the drying is promoted in most machines by means of thick woollen felts, which are made to press against as large a portion of the cylinders as possible, and by means of which the sheet of paper is pressed closely to the cylinders, the drying being assisted by the heat of the felt itself. After being sufficiently dried the paper is passed through a series of highly polished and heavy metal rollers, O, for the purpose of receiving a finer surface, and in many cases two or more of these calender rollers are hollow and heated by steam to increase the effect. The paper is then either at once cut into sheets of the required size by a cutting machine placed at the end of the machine, or is reeled upon wooden rollers to be cut afterwards at a detached machine. The reeling apparatus, P, consists

of a stand, on which four rollers are placed, the ends resting in bearers in a circular disc, and driven by a belt passing round a friction-pulley to prevent driving too fast and breaking the paper. When one roller is full the disc is turned a quarter round, and another roller is brought to the top of the disc; the paper is then broken and passed round the new reel, the old one being afterwards removed and an empty one substituted.

The general process of paper-making being now fully detailed, we will proceed to describe those modifications or additions to this process necessary to produce special descriptions of paper, and of these the most important is that of animal sizing, which is absolutely necessary for all writing papers. The most common way of sizing in the machine, is to place a vat or trough the width of the machine in a suitable position about midway between the drying cylinders: this trough is filled with size, which consists of the gelatine prepared from waste from the tanners, curriers, and parchment manufacturers, and the paper is carried through the size by means of rollers suitably placed, and it is then passed through a pair of rollers which press out the superfluous size, and proceeds at once to the second series of drying cylinders, the first three or four of which are skeleton-cylinders, inside which are a number of fans rapidly revolving, and thus causing a current of air to assist in drying the paper. A more complete arrangement consists in passing the sheet as it comes off the machine through a large vat of size, and then conveying it over a considerable number of skeleton-cylinders in a room appropriate to this purpose and heated by steam; the drying in this case is much slower than by heated cylinders, and the paper thus dried is harder and tougher.

An arrangement now often added to the paper machine, is to place a pair of glazing rolls—precisely similar to the calender-rolls before described, and heated by steam—before the last three or four cylinders. By this means the paper is subjected to the glazing process before it is thoroughly dried, and a much more highly polished surface is the result. This is generally adopted for fine printings and other papers where surface is of importance, as a substitute for plate glazing.

The number of drying cylinders attached to a machine is a matter of great importance, for



PAPER-MAKING MACHINE.

Ref. to Letters.—A, stuff-chests; C, mixing box; D, the sand-catcher; E, lips of sand-catcher; F, trough with strainer-plates; G, endless wire web; H, suction-boxes; J, pulleys carrying deckle-strap; K, dandy-roll; L, couch rolls; M, felt; N, cylinders heated by steam; O, heavy metal rolls; P, reeling apparatus.

unless the paper can be dried sufficiently fast, the speed of the machine is impaired, and the quantity of paper made in the time greatly lessened. The keen competition of late years has led to paper-machines being driven at a much higher speed than formerly, and an increased production from the same machines is the result. Formerly 60 or 80 feet per minute was the usual rate of speed; now many machines, especially on news, are driven at 130 and 140 feet per minute, and this must be perfectly dried when it reaches the end of the machine; so that it is not unusual to see fifteen or sixteen cylinders attached to a machine of this description. Formerly, also, machines of forty to sixty inches were the widest used; recently, many machines making paper over 100 inches in width have been erected; so that although the number of paper-mills is but little, if at all, greater than some years ago, the amount of paper made is very greatly increased.

Much discussion has lately taken place with regard to the best means of straining the pulp before it flows on to the machine, the method almost universally adopted being to employ two or more large strainers, of about six feet by two feet, and when the dirt strained from the pulp accumulates upon them, it is raked to one side and lifted out. This raking of the plates passes through them a considerable portion of the accumulated dirt, and foul paper at the time is the result. To remedy this, revolving strainers have been tried, and more recently strainers in which the pulp is made to flow across the plate in a rapid stream, the residue being carried by the wash off the plate, and further strained by means of an auxiliary strainer, and brought back to the mixing-chest. This is an excellent plan where one kind of paper is continuously made at the machine, but a better and more simple arrangement is to have a considerable number of small strainers in separate boxes, instead of two or three large ones, as the flow of pulp into any one of these can be stopped when the slits are clogged and the plate lifted to be cleaned, without passing any of the impurities collected on it into the vat.

For many papers where uniformity of surface is not of importance, the paper is not passed through the second pair of press rolls: this leaves the paper thicker and more bulky, but with one surface a little rougher than the other.

TECHNICAL DRAWING.—LVI.

GOTHIC STONEWORK.

EARLY ENGLISH ORNAMENTS.

THE most characteristic ornament of this period is that called the "dog-tooth;" but why it has obtained this name is not quite clear, since it is not much like a dog's tooth. It seems most likely that the name is derived from the dog's-toothed violet. It is, however, known as the "tooth ornament," and is really a solid rendering of the zigzag. It consists of a flower of four petals bent backwards, the division between the petals being placed in the middle of the sides of the pyramid thus formed, the pyramid itself being placed on its base against the hollow, with its apex projecting. This ornament varies to some extent in different examples, but always presents the same general appearance. Thus, Fig. 487 is the simplest form, whilst in the group of capitals (Fig. 479) the pyramid is perforated and ornamented.

The position of the ornament is also shown in Fig. 484.

The crocket, the name of which is derived from the French *croc*, a "hook," is an ornament used to decorate the rib or edge running up the angles of spires, pinnacles, gables, canopies, etc. The crocket is supposed to represent the crook of a bishop's pastoral staff; and in this form one of the earliest and simplest is that shown in Fig. 488, taken from Lincoln Cathedral, which exhibits a simple curve turning backwards. Crockets of the Early English style are often simple trefoil leaves, and sometimes bunches of such leaves, placed at considerable intervals and curled backwards. Early specimens are to be seen at Salisbury (Fig. 489) and at Wells.

Finials (Lat. *finire*, "to finish") are, as their name implies, the finishing ornament at the apex of a spire, and consist, as it were, of a bunch of crockets. In the Early English period the finial was made up of foliage in character with the crockets and other features of the style. Fig. 490, from Westminster Abbey, is an illustration of this; and it will be interesting to compare the crockets and finials of this period with those of that which followed, the character of each being distinctly marked.

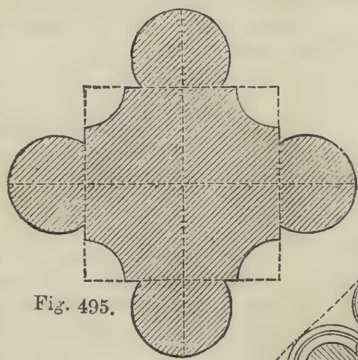


Fig. 495.


Fig. 487.

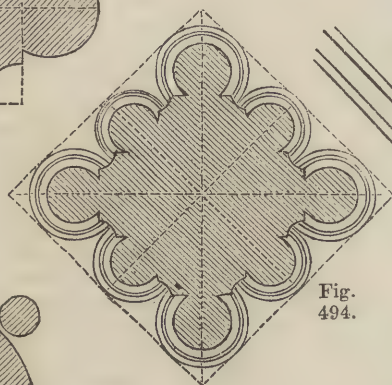


Fig. 494.

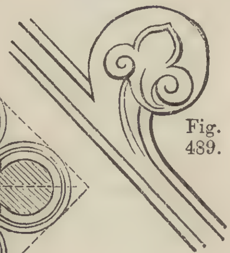


Fig. 489.

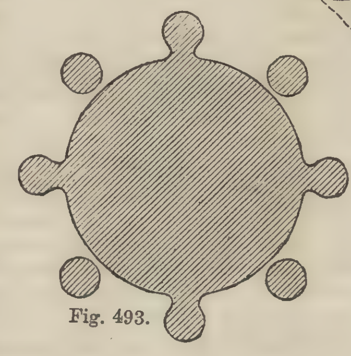


Fig. 493.


Fig. 488.

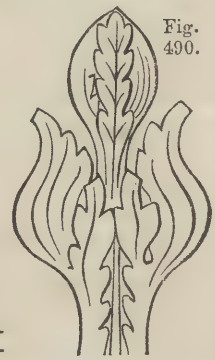


Fig. 490.

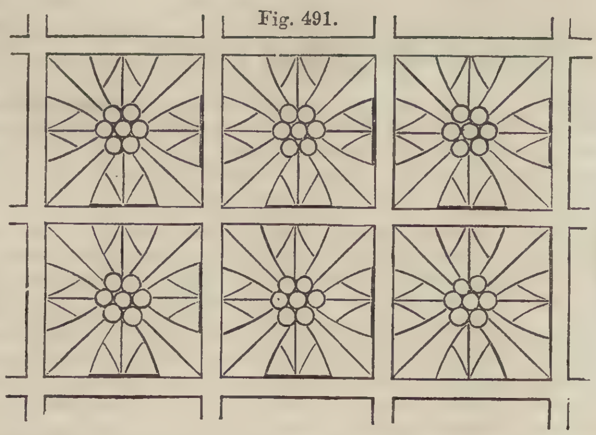
Fig. 491.



Fig. 492.

A beautiful method of ornamenting flat surfaces was prevalent at this and the subsequent periods originating during the Norman time: this was the manner of covering walls or portions of them with what has been called "diapering." The diaper usually consisted of a small flower or geometrical pattern, carved in low relief, the pattern being repeated in separate squares. One of these diapers (from Westminster Abbey) is given in Fig. 491, and the subject will be reverted to further on.

The character of the foliage of this period has been already referred to. The crispness of the leaves, not observable in other styles, although imparting a stiffness, still has a beautiful appearance, being worked with much taste and freedom. Amongst the varieties of foliage the trefoil is predominant; the two lower lobes, and sometimes all three, are worked with a bulb or swelling in the centre, the middle lobe being often larger than the others. Elegant scrolls of this foliage are often placed in the spandrils between arches.

The ornaments carved on the ends of the keystones of the ribs of groined roofs are called "bosses." The character of the ornamentation will be seen in Fig. 492.

If the transition from Norman to Early English was gradual, that from Early English to Decorated was much more so; and we have many curious examples of the different stages of the change. There can be little doubt that Early English was still in use in some parts of the kingdom—unwilling, as it were, to depart from the scene of its triumphs—at the same time that in other localities complete Decorated was becoming general; and thus the terms adopted to designate the different periods must not by any means be taken as definite, or as commencing and closing at any particular date, but merely as indicating the broad classification of the styles and details, and for associating them with particular reigns for convenience in study.

THE DECORATED PERIOD.

This style has been termed the "Middle Pointed" or the

"Edwardian" style, having had its commencement in the reign of Edward I., and arriving at maturity in the reigns of Edward II. and Edward III. It dates thus from about 1307 to 1377, or a little later, and may be named generally the style of the fourteenth century. This was the culminating period of all the beauties of Gothic architecture. It rivals the preceding style in chasteness and elegance, whilst it surpasses it in richness. The wondrous geometrical combinations in the ever-varying tracery; the foliage drawn direct from nature; the exquisite taste with which the construction was decorated, instead of being disguised, all tend to elevate it to the highest rank in mediæval art, and especially so since it is free from the extravagant and redundant ornamentation of the succeeding style.

There is no very novel feature in the arches of the Decorated period. The equilateral is perhaps, upon the whole, the most used, at least in early work; but the drop arch is constantly met with, and lancet, and even small semi-circular arches are found in window tracery, arcades, and niches.

There is, however, one form that may be considered as characteristic of the style—that is, the ogee arch. Although originally introduced into Gothic architecture at a much earlier period, it first came into general use in this country in the fourteenth century. From its constructive defects it is principally confined to the smaller class of work, such as arcades, niches, and the compartments of window tracery; it is also much used as a canopy over an equilateral or drop arch.

The arches of this period have one peculiarity by which they may be distinguished from those of the previous one—namely, that the mouldings frequently run continuously down the piers without being stopped by a capital. These continuous arch-moulds became still more common in the next period.

The shafts of piers in small parish churches are generally of a simple circular or octagonal plan, similar to those of the preceding period; and the capitals and bases must be examined in order to distinguish them. They differ from the Early English examples in being attached to, while in the previous style they were detached from, each other, and most frequently from the central shaft.

The plan of these clustered piers is often that of a lozenge, or of a square placed diagonally. Another shape is that of a quatrefoil; but others, too numerous to mention, are also found. In many instances we see four or more main shafts, with smaller shafts introduced between them. Fig. 493, which is the plan of a pier of the Decorated period, may be compared with Fig. 494 of the Early English and Fig. 495 of the Perpendicular period, the last of which will be described further on.

SEATS OF INDUSTRY.—XXI.

NEW YORK.

BY WILLIAM WATT WEBSTER.

New York, the most populous city on the American continent, and one of the most populous of modern times, is as pre-eminently the commercial metropolis of the New World as London is the commercial metropolis of the Old. The history of this great town will show that it owes its origin, its growth, and its prosperity to commercial enterprise, and to its natural and acquired facilities for carrying on trading operations on a gigantic scale. In 1609 the great English navigator, Henry Hudson, then in the service of the West India Company of Holland, explored the stream since known as Hudson River, and discovered Manhattan Island, on the southern extremity of which the greater part of New York is built. This island, then covered with rocky ridges of primitive gneiss, mixed with hornblende, slate, and mica, and showing evidence of violent upheaval, was, and, for a long period previously, had been in possession of the confederacy of Indian tribes called the "Five Nations," consisting of the Mohawk, Oneida, Seneca, Onondaga, and Cayuga tribes. Traces of a higher form of civilisation, however, than that of those Indian tribes at the date of its discovery, but not so advanced as that of the Toltecs or Aztecs of Mexico, have been discovered in the island and in its vicinity. In 1612 the Dutch laid the foundation of the city by establishing a station for the fur trade at the extremity of Manhattan Island, to which they gave the name of New Amsterdam, and in 1614 a rude fort was erected for the protection of the place. In the following year a settlement was formed at New Albany, on an island immediately below New York; but at this early period there existed no colony; not a single family had emigrated, and the only Europeans on the Hudson were the agents and servants of the Dutch West India Company. It was not till 1624, when Peter Minuits, the commercial agent of this company, brought over a few families, that any effort at colonisation was made. Peter was appointed governor, and retained that office till 1633. In 1626 this worthy managed to *purchase* Manhattan Island from the Indians for some twenty-four dollars! The cultivation of tobacco and the slave system were introduced before the year 1638. Towards the middle of the seventeenth century the colony was frequently harassed by the English and the Indians, and in 1653 a wall was built across the island to resist an anticipated attack from the troops of Cromwell. By the year 1656 New Amsterdam contained 120 houses and about 1,000 inhabitants. In 1658 wharves were constructed, and in 1662 the first windmill was erected. Four years after Charles II. ascended the English throne he granted the entire territory, of which Manhattan Island formed a part, to his brother the Duke of York, considering the occupation of the Dutch an act of usurpation. A small fleet was fitted out, and in August, 1664, the English took possession of the city, and changed its name to New York. For nine years it remained in their hands, but in 1673 the Dutch recaptured it, and re-named it New Orange. In the following year it was restored by treaty to the English, and kept by them till the close of the War of Independence in 1783.

The principal events and facts in the history of New York, during the period of its connection with Great Britain, may be briefly summarised. In 1686 James II. abolished the representative system of local government that had been established by the Dutch in 1652, and granted the city its first charter, which was confirmed by Queen Anne in 1708, and again confirmed, with modifications, by George II. in 1732. A colonial congress was held in New York in 1690; the city was lighted in 1696; a slave market was established in 1711; in 1725 the first newspaper, the *New York Gazette*, appeared; and in 1732 stage coaches were run to and from Boston and Philadelphia. What is known as the "Negro Plot" occurred in 1741-42. On the testimony chiefly of a servant girl, 13 negroes were burned, 20 negroes and one Roman Catholic priest were hanged, and 78 negroes and whites were transported, for alleged implication in a conspiracy to burn the city, which was never satisfactorily proved to have had any existence. In 1750 the first theatre was opened, and Colonial Congresses were held in the city in 1765 and 1776. A committee was appointed to resist the importation of obnoxious goods in 1770, but shortly after it was resolved to restrict the resistance to tea only. The statue of George III. was destroyed, and a marble statue of Mr. Pitt was erected in acknowledgment of the efforts he had made for a repeal of the Stamp Act. Two years later, when Pitt, then Earl of Chatham, had changed his policy, his statue was mutilated by the inhabitants. In 1774 the vigilance committee appointed to resist the landing of tea, stopped a vessel freighted with this article, and sent it back to England. Eighteen chests of the cargo that had been secretly landed were destroyed. After a battle on Long Island in 1776, in which the Americans were defeated, the British troops entered the city, and kept possession of it till the close of the war. In the same year a third of the city was burned to the ground, and two years later 300 houses were destroyed by fire. At the end of the seventeenth century New York consisted of about 750 houses, and its population consisted of about 4,500 whites and 750 blacks. In 1774, previous to the commencement of the revolutionary wars, it contained 22,750 inhabitants, and while the revolution was in progress its population remained stationary. The British evacuated the city, and Washington marched into it in 1783.

Since that period New York has increased with remarkable rapidity. In 1789 Washington was inaugurated first president of the United States at the New York Federal Hall, which occupied the site where the custom house now stands. A year later the population of the city numbered 33,131, and, notwithstanding a severe visitation of yellow fever in 1798, which carried off 2,086 of the inhabitants, by 1800 its population had risen to 60,480. In 1803, 1805, and 1822, New York was afflicted with yellow fever. But at the second of these dates its population had further increased to 78,770, and it may be mentioned that the Free School Society, the germ of the existing

Board of Education, was incorporated in 1805. One of the most interesting and important events in the industrial history of New York, or even of America, took place in 1807. In that year Robert Fulton plied the first steamboat on the Hudson, from a point near the city to Albany; and in 1812 he leased the ferries for 4,000 dollars, and ran steamers between New York and Brooklyn, a suburb on the opposite side of East River. Another great and destructive fire broke out in the city in 1811, and the war between the United States and England in 1812 for a time almost extinguished the foreign trade of New York. Its growth was checked, and the census of 1814 showed a decrease in the population. 1812 is also memorable for experiments with gas that were made in the park, and in 1814 Fulton's steam-frigate was launched. In 1823 a gas company was formed, and two years later gas was in general use throughout the city. The maritime and commercial importance of New York was enormously increased by the completion of the Erie Canal in 1826, which opened up water communication with an exceedingly fertile region, measuring 1,000,000 square miles, traversed by 2,500 miles of navigable water, and containing, at that time, a population of some 50,000, but which is now estimated at considerably more than 10,000,000. New York became the outlet for the produce of the Great West, which had previously been sent to Baltimore by the Susquehanna River, or to Philadelphia by the Schuylkill River. Up to the date of the opening of the Erie Canal, the exports from New York had been drawn exclusively from the regions of the Hudson River and Long Island Sound; since then a system of canals has connected the Hudson, not merely with Lake Ontario and Lake Erie, but with the Ohio, the Mississippi, and the Gulf of Mexico. In 1858 the Erie Canal brought to tide-water 1,496,687 tons of freight, including wheat and flour equal to 3,563,901 barrels of flour, nearly all of which came to New York. About the time when the Erie Canal was started the city was growing at the rate of 1,000 to 1,500 houses per annum. In 1820 the population amounted to 123,706, and in 1830 it was upwards of 213,000. Asiatic cholera caused 4,360 deaths in the city in 1832-34. In 1835 a great fire destroyed 648 buildings, and in 1837 trade suffered from a commercial crisis; but, notwithstanding all these afflictions, the population by 1840 had increased to 312,710.

The following decade witnessed the completion, in 1842, of the Croton aqueduct, one of the most extensive hydraulic undertakings of modern or ancient times. New York had previously suffered from the want of a proper supply of water, which was especially felt when the great and destructive fires we have mentioned occurred. The Croton water-works consist of a pond, enclosed by an embankment of stone and cement, 250 feet long and 40 feet high, which covers an area of 400 acres, and is capable of containing 500,000,000 gallons of water. The aqueduct for supplying this pond commences at a point five miles from the Hudson and forty miles from the City Hall. From the pond the water is conveyed through solid rocks and across valleys and streams, in an aqueduct constructed of stone and brick, in the form of a double arch, 8 feet 5 inches high, and 6 feet 3 inches wide at the bottom. It thus reaches Harlem River, which separates the northern part of Manhattan Island from the mainland, and it is then carried across this river by means of a magnificent stone bridge, 1,453 feet in length, consisting of fourteen arches, and 114 feet above the tideway, and conveyed, first to the receiving reservoir, covering thirty-five acres, and containing 15,000,000 gallons, and thence to the distributing reservoir, about three miles north of the City Hall. The minimum supply of pure wholesome water is estimated at 27,000,000 gallons per diem, and the works are said to have cost upwards of three millions of pounds sterling. Three years, however, after the completion of the Croton aqueduct, another fire broke out, which destroyed 546 buildings, and, in 1849, 5,071 persons died from cholera. During the latter year a most singular riot took place. The friends of the American actor Forrest, assuming that their favourite was displeased at the presence of the English actor Macready in the city, threatened to prevent him from appearing on the stage according to announcement. A numerously-signed requisition from the faction of playgoers that admired Macready, was presented to the actor, and he performed Macbeth at the opera house, intending that to be the first of a series of farewell performances. After the play was over a fight between the rival factions ensued outside the theatre, which had to be quelled by the military. Twenty-two lives were lost, and thirty-six persons were wounded in the *émeute*. Though assured of ample protection by the authorities, Mr. Macready made no further attempt to perform in New York.

The census taken in the year 1850 showed another extraordinary increase, the population at that date having reached 515,710, exclusive of the large suburb of Brooklyn, which, in the same year, contained 96,838 inhabitants. It was calculated that there were then in the city upwards of 80,000 persons employed in manufacturing and mechanical arts; the capital invested in these branches of industry was estimated at fully £6,000,000, and the annual produce at about £2,000,000 sterling. The Collins' line of steamers, trading between New York and Liverpool, was established in 1850; the Erie railroad to Dunkirk was opened in 1851; and the first city railroad was built in 1852. In 1853 an Industrial Exhibition, similar to the London Exhibition of 1851, was held in a crystal palace, 455 feet in length, and with an extreme breadth of 445 feet. By 1855, 19 daily and 126 weekly newspapers, and 78 other periodicals were published in New York. In 1857 there occurred a great financial panic, and a series of riots arising out of a difference between the mayor and the governor of the city, regarding the control of the police force, in the course of which eleven persons lost their lives. Important amendments were made in the charter of the city in this same year, and in 1858 they came into full force. The city was re-distributed into wards; the number of the aldermen was reduced from 22 to 17, and the councilmen from 60 to 24; the mayor and common council were deprived entirely of all control over the police, their salaries were abolished (but have since been restored), and their powers were considerably restricted, the issuing of licences for the sale of stimulants, in particular, being taken from them and vested in a special committee. Recent revelations have shown, in a striking form, that the local government of New York still needs to be radically reformed. The mayor and the heads of departments have salaries of 5,000 dollars per annum.

In 1860 the population of New York proper amounted to 805,551, and Brooklyn contained 266,667. In 1870 the total population of the city and its numerous suburbs and dependencies—Brooklyn, Staten Island, Jersey city, Hoboken, Mount Vernon, Astoria, Flushing, etc.—was estimated at considerably more than 1,400,000. A few items from the statistics of the trade and manufactures of the city in 1861 will show the extent of the most important of its industries at that date. There were then 454 establishments for the working of iron and metal, employing 11,480 persons; 253 establishments making wearing apparel, employing 19,541 persons; 6,049 persons were engaged in the chemical works; 4,912 in the leather manufactories; 4,912 in ornamental arts; 3,699 in making furniture; 3,139 in constructing steam-engines, etc. Shipbuilding has been carried to great perfection in New York, and since 1846 the construction of ocean steamers has been a speciality of the place. In 1851, 208 vessels (including 47 steamers, 11 of which were great ocean steam-ships) carrying a total of 71,214 tons, or nearly one-fourth of the whole tonnage built during that year in the United States, were constructed within the district of New York. In the same year the aggregate tonnage belonging to the port was 931,193 tons, or about one-fourth of the whole tonnage of the Union. New York Bay, or inner harbour, is one of the largest and finest in the world, being completely land-locked, and affording anchorage where all the navies in the world might ride in safety. The entrance to this harbour, called the Narrows, nowhere exceeds two-thirds of a mile, and is exceedingly beautiful, the shore on either side being wooded to the water's edge and studded with villages, farms, and villas. Rows of wharves and piers, the latter numbering about sixty, and averaging from 300 to 200 feet in length, and from 50 to 60 feet in width, extend along the Hudson and East rivers almost without interruption for an aggregate distance of seven miles. Ships of the largest size lie close to the quays, and proceed a great distance up the river. A few years ago it was estimated that the annual value of the merchandise loaded and unloaded in the port of New York amounted to about 500,000,000 dollars, and in the busy season the number of vessels in the harbour ranged from 1,000 to 1,500, exclusive of about 250 steamers. These figures would not represent the trade of the port now; it has since greatly increased. The imports comprise cottons, woollens, linens, iron, hardware and cutlery, earthenware, brass and copper manufactures, salt, etc., from Great Britain; silk, wine, brandy, etc., from France

and Spain; sugar and coffee from the Havannas and the Brazils; tea from China, etc. In the year ending June 30, 1852, the exports were, of domestic produce, 38,853,757 dols.; foreign, dutiable, 5,333,572 dols.; specie, 37,273,703 dols.—making a total of 81,461,032 dols., or £16,292,205. The imports were, of dry goods, 48,900,935 dols.; other dutiable goods, 35,444,896 dols.; free goods, 11,926,912 dols.; specie, 2,528,391 dols.—total 98,801,134 dols., or £19,760,226. The duties collected in the port during the same year amounted to 28,678,910 dols., or £5,735,782, being considerably more than one-half of all the duties levied at all the ports of the Union. In 1858 the value of the exports from New York was upwards of 100,000,000 dols., being one-third of the whole exports of the United States for that year. The exports consist chiefly of wheat and flour, corn, rice, cotton, bullion, beef, pork, butter, dried fish, furs, lard, tobacco, and petroleum. In 1867 the total value of the exports to foreign countries, exclusive of specie, was 186,790,025 dols.; and in 1868 the total exports of specie to foreign parts amounted to 70,793,594 dols. In 1867, 4,676 foreign vessels, 2,053 being British, entered the port, and in 1868 the total number was 4,861, including 2,032 British vessels. Fully two-thirds of the immigrants who arrive in the United States land at New York. In 1854 the number who unshipped at this port reached the highest point it has yet attained, having been 319,223. The average annual number is about 200,000; in 1868, 212,989 immigrants landed at New York. Of the domestic commerce of New York it is difficult to form even an approximately accurate estimate, but some idea of its vastness may be gained from considering the necessities of its population, and the enormous quantities of produce brought thither by its canal and railway systems.

New York occupies an area of about ten miles in circumference. The main thoroughfare, called Broadway, is one of the largest and finest streets in the world, and the favourite promenade of the citizens. It is eighty feet wide, nearly three miles in length, and is almost straight. When the entire plan of the city is completed, this street will be about eight miles long. The part at present constructed contains many fine public buildings, palatial hotels, magnificent mansions, and splendid shops. Wall Street, the Lombard Street of New York, where the offices of the principal stockbrokers and bankers are situated, also contains several of the best public edifices in the city. One of the most notable features of New York is found in its monster hotels. Owing to the great distance between the places of business and the residences of most of the inhabitants, the custom of frequenting hotels and restaurants is all but universal. Large numbers of persons, married and single, moreover, permanently reside in hotels, and pay fixed weekly rates for their board and lodging. The oldest of the great hotels of New York is Astor House, in Broadway, erected in the year 1839 by John Jacob Astor, then the richest man in America. It is a massive granite structure, six stories high, with shops on the ground-floor. It contains some 600 rooms, and can accommodate 1,000 guests. The most expensive and luxurious of the New York hotels is the Fifth Avenue Hotel, an edifice in white marble, six stories high, which can also accommodate 1,000 guests. There are several other hotels in the city on an almost equally extensive scale. Among the most imposing public buildings deserving special notice is the New Exchange, built in granite, in the Grecian style, to replace the old Exchange burned in 1835. Including the price of the site, this edifice cost 1,175,000 dollars. The City Hall, which occupies a commanding position in the centre of the park, is 216 feet long and 105 feet wide; its front and sides are of white marble. It is entered by a flight of twelve steps, and by a double staircase which leads to a circular gallery, floored with marble; and above the whole rises a cupola, surmounted by a gigantic statue of Justice. The Common Council-room is very handsome. On the site of the old Federal Hall stands the Custom House, a marble edifice on the model of the Parthenon at Athens, approached by a flight of eighteen marble steps. The oldest educational establishment in the city is Columbia College, formerly called King's College, founded by George II., in 1754, which has a president and eight other professors, is attended by about 150 students, has a library of 25,000 volumes, and an estate valued at about 500,000 dollars. Attached to this college is a preparatory grammar-school, where about 300 scholars are taught. The University of the city of New York, founded in 1831 and opened in 1832, occupies a fine marble building in the English collegiate style. It has a chancellor and eleven professors, and its art students annually average about 150. The medical department has several professors and about four times as many students as the arts' department. There is in New York, besides, a College of Physicians, with six professors and a large number of students. The city contains several theological seminaries, prominent among which are the Union Theological Seminary, and the Protestant Episcopal Church Theological School. The Free Academy, a handsome Gothic structure built at a cost, inclusive of furniture, etc., of £16,000, now one of the most important high schools in the city, was erected in accordance with a vote of the citizens taken in 1846, for the purpose of extending additional gratuitous instruction to the former pupils of the common schools of the city and county. It has eleven teachers and some hundreds of pupils. There are numerous important literary, scientific, and artistic societies in New York; and it contains many excellent and extensive charitable institutions. Cooper's Institute, or the "Union," founded by Mr. Peter Cooper, at a cost of £62,500, comprises a free reading-room, picture gallery, art schools, etc. The Astor Free Library, founded by the American millionnaire of that name, contains upwards of 100,000 volumes; and New York can boast of several other large and valuable collections of books. In 1860, a woman's library, the first in America, was opened in New York. There are considerably more than 250 places of worship in New York, and many of them are costly and magnificent structures. Trinity Church, though only affording accommodation for 900 worshippers, and built in brown sandstone, cost £80,000. The Roman Catholics, the Presbyterians, the Congregationalists, the French Protestants, and the Dutch Reformers, all possess fine churches in the city. The Jews have twelve synagogues. New York is not particularly well provided with places of amusement, but it maintains several theatres, which are much frequented. There are eleven markets in the city. The streets are traversed by upwards of twenty lines of tramways, and splendid fast steamers run across the ferries to the various suburbs every few minutes during the day. Originally, New York was built of wood, and the streets were very narrow, but most of the old houses have been pulled down or burned, and replaced with houses of brick. The sanitary condition, and the paving and lighting of the city have been greatly improved, but it is not, even now, as a whole, on a level with most other large towns in these respects. The new streets are broad and regular, well paved and lighted, but in the more ancient and poorer quarters there is room for very great reform. In New York the practice of selling goods by auction, and especially goods imported from abroad, has long been in vogue, and is still a peculiarity of the city. Auctioneers there are appointed by the Senate, on the nomination of the Governor. Nowhere in America has banking been more abused, or has greater evils flowed from its abuse, than at New York. In 1863 there were no fewer than 309 banks in the city, organised on the security principle—the banks being obliged to deposit security proportionate to the amount of the notes they were empowered to issue. The publishing trade is very extensive. From the numerous presses of New York upwards of 250 periodical publications are issued, including, as it has been said, 19 daily, 126 weekly newspapers, and twelve quarterlies. There are thirteen German, two French, one Spanish, and two Welsh newspapers published in the city.

SANITARY ENGINEERING.—XV.

DRAINAGE AND WATER-SUPPLY.

In approaching this branch of our series we couple these two subjects for this reason, that the scope of our present space does not include *water-supply* in its most extensive and important engineering aspects; while at the same time throughout the country, with very few exceptions, the great proportion of the drainage—under which general head we intend to include all domestic appliances—is dependent for its efficiency upon a good supply of water. The course we therefore propose to take is in this paper to give a short summarised description of the ordinary methods available for obtaining an efficient supply of water for villages and small country towns; and in the next a similar sketch of the ordinary circumstances of what we may

call metropolitan water-supply, as at present in operation in large towns, such as London, Liverpool, and elsewhere. And we may make the remark that one most important sanitary point to be kept in view is, that the water-supply shall be absolutely and entirely free from any connection with the drainage. A surface well of small depth, for example, in the neighbourhood of drains in an imperfect state is a most fertile source of disease, especially in what are called "cholera times," and the greatest precautions should always be taken to prevent any communication between the one and the other. There are other sources of danger to the public health, to which we shall only so far allude as to quote a single instance of the disastrous effects of impure water. During the last epidemic of cholera in this country, in one particular village 400 deaths took place within a very short period; and such a terrible disaster led to a scientific inquiry. It was found that the principal water-supply of the village was obtained from a well which was much in favour, because its water was bright and sparkling in its appearance. Chemical analysis, however, showed it to be highly charged with decomposed animal matter, and a careful examination showed that the only source from which this could possibly arise was that there was an underground drainage below the surface into the well from a neighbouring churchyard. This is, no doubt, an extreme case; but we quote it to show the great importance, in a sanitary point of view, of a pure supply of water. Into this particular branch of the subject, however, we do not go at greater length, and proceed at once to the consideration of the quantity of water required per head per day for all necessary domestic and sanitary purposes. We may remark that the quantity actually consumed varies very much in different localities. In healthy agricultural districts less water is really required than in confined and smoky towns. Authenticated returns show that the consumption at the town of Lynn, in Norfolk, is 50 gallons per day; while at Stroud, in Gloucestershire, 10 gallons only are used. This last figure may be taken practically as the minimum required; and we may mention that one of the first hydraulic engineers of the day recently made some observations by measurement of the quantity of water actually used day by day in his own house, which was fitted up with every convenience for comfort, and had more than one bath in pretty constant use. It was not a large mansion, but a gentleman's residence of moderate dimensions; and he found that the average quantity was 11 gallons per head per day. We may, therefore, take it that 10 gallons is a perfectly ample and sufficient provision, if properly available, for a general population. When we come subsequently to deal with the question of metropolitan water-supply, we shall find other disturbing influences at work, and shall have much larger figures to deal with. Our only object at the moment is to give some reliable data as to the quantity of water required for daily consumption, in proportion to the population of any particular village or district; though, of course, there is this advantage in a superabundant supply, that flushing and other operations in connection with a system of drainage can be more frequently and efficiently carried out.

We now turn to the various resources at command for village use, and how they are best available. A well, a stream, and the careful storage of rain-water are what we may call primary sources of supply, and neither of them is by any means necessarily insufficient. There are cases of country residences where the roof-area is tolerably large, and the constructional details well considered, where the rainfall alone, conducted by gutters and pipes to well-cemented cisterns underground, suffices for the entire supply of the house in all seasons from year to year; but these cases are exceptional, and we now take up the other sources from which a permanent supply can be ensured and laid on throughout a village. These may be divided into three:—First, a supply in the neighbourhood above the level of the village, either a stream or the rainfall from neighbouring hills. This supply is generally ample, but intermittent in the winter months, though there may be plenty of water for use all the year round; but this may not be available in the summer. What is requisite is manifestly a reservoir or means of storing the water; and to ascertain what the size of that reservoir should be, we refer to the figures we have last quoted as to necessary consumption, and assume for example that a supply is required for a village of 400 inhabitants. At 10 gallons per diem this gives a total annual consumption of 1,460,000 gallons, one-half of which should be stored for use in the dry months, allowing 50 per cent. for waste, evaporation, etc. Assuming a depth of 10 feet, the size of the reservoir should be about $\frac{4}{10}$ of an acre, and the cost of its construction may be roughly stated at £400. The supply being thus secured at a level sufficiently high to reach without difficulty the roofs of the houses, the laying on the water becomes a mere question of cisterns and plumbers' work, into the details of which we propose to enter upon a subsequent occasion. Financial questions—*i.e.*, where the money is to come from—are beyond our limits; but the question of rates, advances, outlay, and return or profit are obviously mere matters of calculation, after the first provision has been properly made.

In many cases, however, a reservoir at a level sufficiently high is not attainable, as the village itself may be situated upon the highest land in the district, and must therefore be dependent for its supply from below; and this brings us to the second branch of our subject, a supply in the neighbourhood a little below the general level—*e.g.*, a running stream. There, machinery to raise the water to the requisite height must be brought into play, and for this class of supply three different systems may be adopted—the hydraulic ram, the turbine, and the undershot wheel. The action of the hydraulic ram avails itself of the fall of a large body of water for a short distance, to throw a smaller quantity to a considerable height; and the profitable limit at which it can be employed, is when the height to which the water is to be lifted does not exceed twelve times the fall available. The fall to the ram should never exceed 20 feet, as then the strain upon the valves becomes too great. We cannot afford the space to explain at length in this paper the principles of the turbine and the undershot wheel, but only quote from a reliable authority some figures showing the comparative cost of the different systems, upon a parallel scale with the figures already quoted.

An hydraulic ram with a fall of 8 feet, and capable of raising daily to a height of 40 feet, and a distance of half a mile, 4,000 gallons of the same water by which it is moved, with a supply-pipe to the village half a mile long, but exclusive of connections with dwellings, etc., will cost about £360.

A turbine working with a fall of 20 feet, capable of raising 10,000 gallons daily to a height of 100 feet, with pumps and rising main for forcing the water to a distance of half a mile, but exclusive of connection with dwellings, will cost about £650.

A water-wheel capable of doing the same work as the turbine, but working with a fall of only 3 feet instead of 20, with pumps and rising main but no connections, may be taken at £750.

The peculiar circumstances and situation of the locality must determine which of these various methods of supply it is most advisable to adopt, when the source of the supply is a short distance below the general level of the village or town requiring it.

We now come to a third branch of the subject, and that is, when none of these resources are available, and the only course is to obtain what we may term a subterranean supply from a deep well. The facility of obtaining water by this means extends very widely over the country. On the greensand formations, the new and old red sandstone, and the lower outcrops of the chalk, there is a source which is practically inexhaustible; and the well being sunk, we have at our command various means of raising it to the surface—viz., wind, horses, and steam-power. Of these the wind is the cheapest, but as it is not always available, it is desirable to have the machinery so arranged that when there is no wind it can be driven by horse-power.

The number of days on which the horses would be required to work would vary, of course, with the locality, but perhaps 100 days throughout the year may be taken as a minimum; this result may again be modified by the construction of an intermediate reservoir large enough to meet the requirements of the various intervals. Where the depth, however, is not great, and the quantity of water required small, the old-fashioned revolving chain of buckets may still be used with advantage, as it can be readily repaired when required, and kept in order by any village blacksmith. For deep wells, however, force-pumps are required, with their attendant engineering appliances; and in many instances, especially in the coal districts, the introduction of steam will be found more economical than horse-power. Here again our limits admit of no figures in detail—steam-pumps and steam-engines, as applicable to water-supply, being literally legion in number, variety, and expense.

Having thus briefly indicated the various sources of supply for what we may call country districts, we may remark that in the erection of a house or mansion of any extent at a distance from

any already existing source of supply, our previous remarks are applicable, and a sufficient supply of water should always be one of the points to which attention ought to be carefully directed. We heard lately of an extreme case where the question was thus raised late in the day. The proprietor called in a consulting engineer, who immediately reported that one cistern of 500 gallons contents was all that had been provided for the supply of a mansion where the daily consumption would be at least 3,000 gallons. Let us trust that similar cases are of rare occurrence.

Reverting to what we may call the general question, we may say that at the present moment the most important element in the drainage question, from a sanitary point of view—taking the kingdom generally, and what we may call the general practical position of these matters at the moment—is an ample supply of water. Other systems are in operation to a limited extent. We shall have occasion in the course of the current series to notice Moule's earth-closet, in which a totally different process is adopted, and the sanitary résult to be obtained is arrived at—and successfully, as we believe, to a certain extent—by altogether different means. Other methods for the disposal of sewage are also in process of consideration by different public bodies; but taking the broadest view of the question, and the means at present at our command for evolving the best sanitary results from the appliances at our command, we may lay down the general principle, that the more ample the supply of water in any particular locality, the better conducted will be the drainage generally; as with regard to the removal of all objectionable material, the first and simplest process at our command is to *wash it away*. We therefore preface our papers upon the subject with this brief summary of the best available methods for village water-supply; and had we the requisite space at command, we might perhaps astonish our readers by showing in how many districts the facilities for water-supply above described are *not* available. In our next paper we propose to deal with the question of metropolitan water-supply considered from the same point of view, in relation to drainage; and then we shall venture upon the subject proper, as we may call it, and endeavour as best we may to give a technical description of the various mechanical appliances available "with an ample supply of water," *the first requisite* to maintain a perfectly healthful and satisfactory system of drainage.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VI.

BY E. WYNDHAM TARN, M.A.

MASONRY.

Stone is used for the building of walls in a great variety of forms. The commonest kind of building is the rubble-wall, which consists of small rough stones placed together either dry or bedded in mortar; bond stones being introduced for the purpose of tying the two faces of the wall together. Rubble walling is measured either by the cubic yard, entering length, height, and thickness, in the dimension book under each other and cubing; or else the superficial area is taken, deducting openings, the thickness stated, and the quality of the work described as dry-walling, random-walling in mortar, coursed-walling, hammer-dressed on the face, etc. The bond stones are measured separately as cube stone, but their size is not deducted in measuring the wall. Where flints are used for walling, the dimensions are taken in the same way as for rubble walls, describing whether the flints are used rough, split, or worked.

Where the rubble wall has a thin ashlar facing of superior stone, the wall is measured as before described, and the ashlar taken separately by the superficial foot. If the ashlar is above 6 inches thick it must be cubed, and the labour on bed and face measured separately by the superficial foot; the same plan is to be adopted if the wall is built of solid ashlar, or hewn stone throughout.

In measuring hewn stone, take the cubical dimensions of each stone separately, as those of the smallest rectangular block which it could be got out of. Then measure separately the labour upon each face by the foot superficial as plain beds and joints, plain tooled or rubbed work, sunk work, circular work, sunk circular work, moulded work, circular moulded work; girting the mouldings in the two last items.

In measuring the labour in getting out the voussoirs of an arch, take one bed as superficial of plain bed, and the other bed as sunk work. The soffit is taken as superficial of circular work if left plain, and if moulded the moulding is girt and taken as superficial of circular moulded or sunk work; but if the moulding girts are less than 6 inches, take it as run of circular moulding in addition to the plain circular of the soffit.

When large stones are required which measure over 6 feet in length, they are taken separately and described as scantling lengths.

If stones have to be sawn in two, measure the sawn surface of each, and describe as superficial of half-sawing.

Spandril steps for staircases are usually got out by sawing a block such as A B F E (Fig. 3) in two, upon the diagonal line D C, so as to get two similar steps out of one block of stone. In measuring take the net cubical contents of each step, allowing ½ inch all round for working; that is, the extreme length A B by half the height A D. Measure the soffit as half-sawing, then the tread, riser, and soffit as superficial plain work rubbed, take the girt of the rebate at D by its length as superficial sunk work. If the step has a moulded nosing, then the riser must be taken as superficial sunk work, its width from the nosing to the rebate by the length of the step, and the girt of the moulding, by the length measuring round the return end, is taken as superficial of moulded work. The outer end of a spandril step is measured as superficial plain work, unless there is moulding, when it is taken as sunk work, and the moulding as above described. Number all mitres to moulded nosings, ends cut and pinned into walls, holes cut for balusters, etc. If there are winders to the spandril steps, they are measured in a similar manner, but with a greater allowance for waste, and the soffit is taken as superficial of circular sunk work.

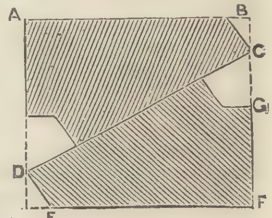


Fig. 3.

Landings that are less than 6 inches thick are measured by the superficial foot, and the thickness stated; if 6 inches and upwards, they are cubed, but kept separate from the other cubed work, and described as "cube landing." The labour on the top and bottom and outer edge is taken by the foot superficial as plain work rubbed or tooled, and any mouldings are girt by the length and entered as superficial of moulded work. Where the landings are formed of more than one length of stone, the joints are joggled, thus (Fig. 4): the joggle and its groove are to be girt and taken by the length of the joint as superficial of joggled joint. If one edge of the landing is cut and pinned into the wall, take its length as run of cutting and pinning; but if built in as the work proceeds, this is stated in describing the landing itself, and is not measured separately. Joggled joints to landings under 6 inches thick can be taken as running measure, describing the thickness of the landing in which they occur. If there is a throating to the landing, take its length as run of throating.

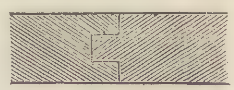


Fig. 4.

In measuring window sills, take the length by the width by the thickness, with an allowance for waste, as cube stone if not less than 6 inches thick; take the whole of the top as superficial of plain bed, measure the top, front, projection, and ends as superficial of plain work, and the sloping or weathered portion of the top as superficial of sunk work. For thin sills take the length only as running measure, describing the dimensions and work upon them; number the returned fair ends and all stoppings. Throating to sills is taken by the foot run. If the sill has a moulded front, its length is taken by its girt and described as superficial moulded work.

String courses are measured in the same way as sills, taking one plain bed and the projecting part as plain work, sunk work moulded work, as the case may be; number all mitres and stopped ends.

Cornices being generally formed of stones which bed upon the wall at least as much as they project therefrom, the exact width of stone must be ascertained and measured as cube stone, with proper allowance for the waste in working. If the stone has to

be sawn, measure the face and back as superficial half-sawing. Measure the top and bottom beds where the stone rests in the wall, and also the ends of each stone, as superficial plain bed. If the top is weathered, take as superficial of sunk work the length by the width of the weathering. Girt the moulding, and take it by the length as superficial of moulded work. If there are grooves cut in the joints for running with lead, take their length as run of groove, the quantity of lead being taken by weight. Plugs and cramps are to be numbered; also number all mortise holes, notches, mitres, etc. Dentils, consoles, or other ornamental features in a cornice, must be numbered and described with a sketch showing the design, and their size given. If there is a blocking course above the cornice, measure its cubical contents as before described, take the superficial of the beds and joints as plain bed, the superficial of plain work to front and top, and half-sawing to the back; and any moulded work as before described. Number all plugs, cramps, etc., and take the run of grooves, and weight of lead used in running thereto.

In measuring stone columns, take the shaft separately from the cap and base, measuring the cube of each stone required in forming the shaft with allowance for waste in working; if there is a fillet and hollow included in the top and bottom stones of the shaft, the dimensions of those stones must be taken outside the fillet. If the shaft is got out of a single block, it must be so stated and the length described. Measure all the plain beds to the jointings of the shaft, and take plain work on two sides of the block; measure the circumference or girt by the length as superficial of circular plain work, unless the shaft has a curved outline or entasis, when it must be taken as circular sunk or circular moulded work. Girt the mouldings to the fillet and hollow at top and bottom by the circumference as superficial of circular moulded work. Number all dowels, mortise holes, etc. In measuring the capital and base, take the cubical contents with allowance for waste, measure the superficial of plain bed on the top, sides, and bottom of the stones, girt all the moulding by the circumference, and enter as circular moulded work.

Where the capital is carved, a sketch or description must be given, and the carving taken at each. Flutings to columns are taken by the foot run, and the stopped or rounded ends numbered.

Thin coping stone is generally taken by the foot run, and described as weathered and throated one or both ways, tooled, rubbed or quarry-worked, the width and thickness being stated. If the coping is more than 3 inches thick, take the cube of the stone and the superficial of the labour on the top, front, and projection, whether saddle-backed, weathered or otherwise, and take the run of the throating. Measure the plain work to one joint of each stone.

Moulded architraves are measured by taking the cube of the stone required for getting out, and the superficial of the moulded and plain work; numbering the mitres, dowels, plugs, stopped ends, etc.; and measuring one plain bed to each stone.

The quoin stones of building are cubed, and the superficial of plain work on the face taken; also the superficial of chamfered or moulded work, rustication, sinking, etc.; one plain bed of each stone being measured, and also the joints next the walling.

Flagged paving from 2 to 3 inches thick is taken by the superficial yard, and described as quarry worked, tooled, or rubbed. If edges have to be cut to paving, take the cutting by the foot run.

Paving with sets, as Elland-edge or granite, is measured by the superficial yard, the concrete bottom for the same being taken separately. Curbs are taken by the foot run, describing the quality, dimensions, and labour.

Sinks are measured by the foot superficial, their thickness stated, rebated holes and rounded corners numbered. Templates built into walls, stone core for cement cornices, slabs, and hearths, are all measured by the foot superficial, including the labour employed upon them, the thickness being described.

The labour to the tracery of Gothic windows is measured as superficial circular moulded work, taking the outline of the tracery by the girt, numbering all mitres and cuspings. Run the length of the groove for glass, and number the holes for saddle bars. The mullions are taken in the manner described for measuring columns.

Marbles used in slabs are taken by the foot superficial, including polishing. Cramps for fixing marble are numbered. Marble or granite columns are measured by the foot run, describing the diameter, and if diminished or curved. Marble chimney-pieces are generally numbered and described, but plain mantel and jambs are taken by the foot superficial.

FORTIFICATION.—VIII.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DETAILS OF FIELD WORKS.

In the construction of works a knowledge of numbers of details is essential. Some of these, being mere matters of building and ordinary construction, will not be dealt with here; but there are others which, either from their connection with the artillery armament, or from their being universally employed by military engineers in the field, are necessary for any student of the art of fortification. The object of all fortification being to enable the defenders to use their weapons with the greatest possible facility and effect, the details of the works must be carefully designed to suit the armament for which they are intended; and it follows that whenever a new invention or improvement is introduced in either the guns, carriages, or projectiles, there must almost necessarily be some modification of the details of the work to adapt it to the new conditions. For this reason, details which to-day are necessary may in a short time become obsolete. Some of the details of field-works, however, are not liable to much change, from the fact that generally only certain materials are available in sufficient quantities in the field; and the methods of employing these are almost identical in most of the armies of Europe.

Revetments in Permanent and Field Works.—In order to economise interior space, and to allow of the free working of the guns, the interior slopes, the sides and ends of traverses, and the walls or sides of field powder-magazines are usually reveted. In permanent works the escarp and counterscarp of the ditch are generally massive walls of considerable height; and the question of revetments becomes one of the most difficult and expensive portions of the scheme. In field-works the slopes are seldom of any great height, and can be retained at a sufficiently steep inclination by any of the following materials—viz., fascines, gabions, hurdles, sods, sandbags, casks, planks.

Fascines.—A fascine (Fig. 53) is a neatly-made fagot of large brushwood, about 9 inches in diameter and 18 feet long, though it may be sawn off at a shorter length if required. In making a fascine, first lay out on the ground a rectangular space, 16 feet long by 4 feet broad, and at each end of it construct a low tressel by driving two stakes about 6 feet long obliquely into the ground so as to cross at about 2 feet 6 inches from it, the upper projections of the cross being about 2 feet long. These are then firmly lashed at the points where they cross, and a line is strained from one tressel to the other. Three other similar tressels are made between them, at 4 feet intervals, and lashed at the level of the line. The brushwood is then laid on the cradle so formed, all branches that will not lie evenly being removed; care must be taken that the brushwood is so laid on as to form a fagot equally thick throughout its length. The brushwood before being tied is compressed to the required size by means of an implement called a fascine-choker (Fig. 55), consisting of a pair of wooden levers 4 feet long, connected by a chain about the same length, on which two small rings are fixed 28 inches apart. The chain is placed round the fascine, and the levers are pressed down by two men until the rings are opposite to one another. Before the choker is removed, the fascine is bound or tied with wire, rope, yarn, or a twisted brushwood withe. Two men are employed binding, and commence about 9 inches from the end close to the choker. The fascine is bound in twelve places, at intervals of 18 inches, and the ends of the brushwood are sawn off so as to make it 18 feet in length. The size of the brushwood, and also the time of year at which it is cut, will affect the weight of the fascines, but on an average it is about 140 lb. They employ five men each, who should finish one fascine in an hour. Fascines are employed in various ways in the construction of works, and are a means of utilising brushwood for reveting purposes which would be too brittle for gabion or hurdle-making. A fascine revet-

ment will stand at a slope of $\frac{4}{1}$, and is built as follows:—First dig a narrow trench, about 3 inches deep, along the foot of the intended slope, and in it place a fascine, which should be firmly picketed to the ground. The other fascines are then placed one above another, each row being picketed to the earth in the parapet and to the one beneath it, the earth backing being filled in and rammed as the revetment proceeds. In light sandy soil, or where the revetment is either required to stand for some time or is liable to be disturbed by the effect of the enemy's fire, a fascine, log of wood, or stout pickets should be buried in the heart of the earthwork, and attached by wire or lashing to one or more rows of fascines, so that they cannot slip forward without dragging this anchor with them. Fascine revetments last fairly well, but are somewhat tedious to make, as the parapet has to be formed simultaneously with the revetment; in addition to which it has the defect that if a fascine is displaced by the bursting of the enemy's shells in the parapet, not only is that particular one brought out of position, but probably all the other rows resting upon it are brought down also.

Other Uses of Fascines besides Revetments.—Fascines are generally used with gabions in forming a revetment, and are of great use in the formation of the roofs of blindages or other covered parts of field-works which have to resist the effects of shells falling on them. In road-making over marshy ground, and in the difficult and dangerous operation of crossing the wet ditch in the attack of a fortress, they form an important item in the materials required by the engineers.

Gabions.—Gabions are cylindrical baskets, with open ends, 2 feet in diameter and 3 feet high. They may be constructed of brushwood, sheet iron, or hoop iron. The ordinary brushwood gabion (Fig. 56) is thus formed—viz., three men are employed, one of whom prepares the brushwood; another holds the upright pickets, and takes care that the gabion as it proceeds is symmetrical and of the right size; while the third weaves the brushwood. A circle 11 inches in radius is traced on the ground, and ten or twelve pickets, about 3 feet 6 inches long, are driven in round the circumference at equal distances from one another. The number of pickets used must depend on the size of the brushwood, which if large will not bear being frequently bent. In the Prussian service the brushwood gabions are woven on the same principle as our iron band gabions, and have only seven pickets. Three long rods, stripped of small twigs and leaves, are then placed with their butt-ends resting each against a picket, and the weaving begins. Each rod is in turn taken outside the two pickets next it and inside the one beyond. This is continued until the gabion web or waling is $2\frac{1}{2}$ feet high, care being taken to press the rods down on one another as the work proceeds. When a rod breaks or is too thin for further use, a fresh rod is inserted, its butt resting against the inside of the last picket touched by the one it replaces, and the two are then worked as a single rod. The ends of the gabion are now finished by two pairing rods, which after being well twisted, so as to prevent their breaking, are inserted one on either side of a picket, and are then woven alternately inside and outside the pickets, and over and under one another. Their ends are finally inserted on either side of the picket next beyond the point at which they began. The gabion may now be taken out of the ground, and after being similarly finished with pairing rods at the other end, the pickets are cut off at a height of about $1\frac{1}{2}$ inches above the web, making the dimensions of the finished gabion 2 feet 9 inches in the web, and 3 feet from end to end of the pickets.

To prevent the web from slipping off the pickets when moving the gabions about, it is sewn as it is called, *i.e.*, brushwood withes or lashings of some sort are passed over the pairing rods in three places at each end of the gabion, and with each of these lashings three stitches are made as shown in Fig. 57, so as to bind the whole of the web together. A brushwood gabion weighs from 35 to 50 pounds, and takes three men about two hours to make. The hoop-iron gabion was first used at the siege of Sebastopol, owing to the difficulty of obtaining sufficient brushwood. It need not be described, as it has been much improved upon by Quartermaster Jones, R.E., who invented the iron band gabion (Fig. 58). This consists of ten bands of galvanised iron, each 6 feet 5 inches long, and 3 inches in width, having two buttons at one end and two slots at the other. The ends of the first band are buttoned together, and it is placed on its edge in a circle. Twelve pickets are then driven round the circle, alternately outside and inside it. The other bands are in succession buttoned round the pickets at the top, and pressed down on the bottom one. Two men can make one of these in five minutes, as they require no sewing.

They have the advantages of durability and lightness; moreover, as these bands can be so readily put together, they may be carried in bundles to the required spot, and made up there. Their defect is that they are liable to cause many wounds by their splinters if struck by a shot. Gabion revetments are built as shown in Fig. 59, and are generally used in the construction of siege-batteries and parallels, in preference to other materials, on account of the rapidity with which the revetment is built and cover obtained; moreover, when struck by shot the damage produced does not extend so far as in a fascine revetment, for instance. In building it, a fascine is first laid longitudinally along the foot of the intended slope; the gabions are then placed in a row touching one another, with their inner pickets over the centre of the fascine. This gives the requisite slope, $\frac{4}{1}$. The pickets are driven into the fascine, and the gabions are now filled with earth. A little care is necessary in first filling the gabions to prevent their being knocked over by the earth thrown at them when nearly empty; but practically very few men are required for this, and it is a great advantage to be able to get rid of the builders of the revetment when actually throwing up the earth, especially when the work is being carried on at night, and the earth is being obtained from the interior of the work, in which case it has to be thrown over or past the men who are building. When the parapet reaches the level of the first row of gabions, a fascine is firmly picketed on the top of them; and should a full parapet of 7 feet 6 inches or 8 feet be required, a second row of gabions is placed and filled. Gabions are sometimes used in road-making, to assist in forming drains; and in camps they may be usefully employed as a means of forming rough filters at places from which buckets can be filled without disturbing the mud in a stream. When so employed they should be sunk in the ground, and packed round with a foot or two of coarse sand, gravel, or brushwood.

Sandbags are very useful for revetments, because when empty they are very portable, and can be carried up in large numbers and filled at the required spot; they moreover require little or no skill to build, and enable batteries and parapets to be reveted and finished in places where no brushwood is to be had. The bags used in the English service are 2 feet 8 inches long, by 1 foot 4 inches broad when empty, and contain rather less than a cubic foot of earth. They are built in courses, as in brickwork, at a slope of $\frac{4}{1}$. Each row of bags is laid alternately as headers or stretchers, *i.e.*, if one row is laid lengthwise along the parapet, the next row above is laid with their length at right angles to the slope. Two men can build about thirty-five per hour, if the bags are filled and brought to them. Sandbags are of great use in the latter part of sieges, and also in the hasty defence of houses, etc., because two sandbags placed together are bullet-proof; and in the above-named cases protection from rifle-fire is what is principally wanted.

Sod revetments form a neat-looking slope, and stand at $\frac{3}{1}$; they are, however, tedious to build, and are not a very reliable means of retaining earth. They are laid in courses, like sandbags, each course being pegged to the one below it. They are usually cut 18 inches long, 9 inches wide, and 4 inches thick; but when built in revetment they occupy much less room, their number being generally estimated at five per square foot of revetment.

When hurdles or planks are used, they are kept in position by stout pickets, which should be anchored to something buried in the heart of the parapet, to enable them to withstand the pressure of the earth.

Traverses are mounds of earth thrown up inside a work, with the object of affording more protection to the defenders than would be given by the parapets alone. When they are intended to check enfilade fire, they should be almost as thick as the parapets themselves, and are usually reveted on the side which is not exposed to fire. In permanent works, and sometimes in field-works also, expense magazines, shell-rooms, or some other bomb-proof accommodation is provided under them; great care being taken to form the roof of railway iron, covered with fascines and earth, or with other material that will give the necessary security.

To protect the men working the guns in a work from the destructive effect of the shells bursting near them, it is necessary

to construct splinter-proof traverses. These are generally reveted with gabions, and are about 16 feet long, and 4 feet thick at top. They are sometimes detached from the parapet, so as to allow the men to pass close to the parapet between the gun portions. One of these traverses used formerly to be placed between each pair of guns or mortars; but where economy of interior space is not required, this number may be advantageously increased.

In the approved type of screen-battery for sieges, a broad solid traverse, containing a recess or passage for filled shells, is placed between every gun or mortar; and in the Confederate batteries employed for the defence of Charleston Harbour each gun was isolated by having a traverse between it and its neighbours are traversed from right to left on two curved iron ribs or racers let into granite blocks which are sunk to the level of the ground. There are three types of wooden platforms used in the field by our army, viz., Pasley's, Alderson's, and Colonel Clerk's (Fig. 60).

Pasley's platform (*f*) consists of a number of (five) sleepers sunk in the ground parallel to the line of fire of the gun; these are sunk nearly to the level of the ground, but slope upwards to the rear at $\frac{1}{15}$. On them a flooring of planks is laid, which in turn is secured by two side-pieces or ribbands, lashed or racked down to the sleepers. Pasley's gun platforms are 15 feet long and 10 feet 6 inches wide; and the mortar platforms 7 feet 6 inches by 5 feet 6 inches. Either of these can be laid by four men in an hour.

Fig. 58.

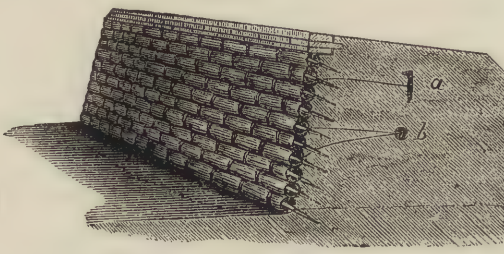


Fig. 54.

Fig. 56.

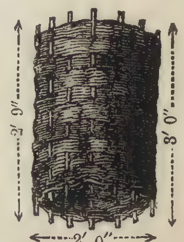
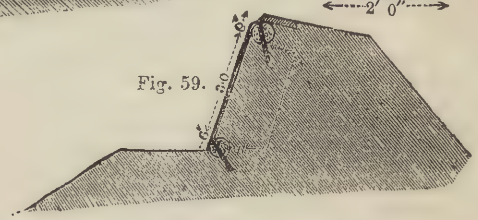


Fig. 53.

Fig. 59.



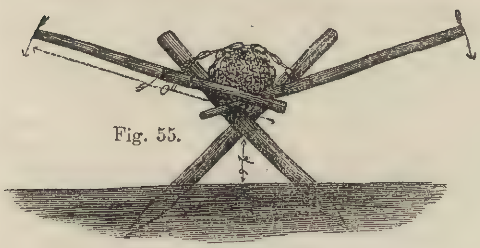


Fig. 55.

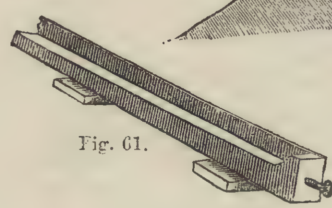


Fig. 61.

Fig. 60.

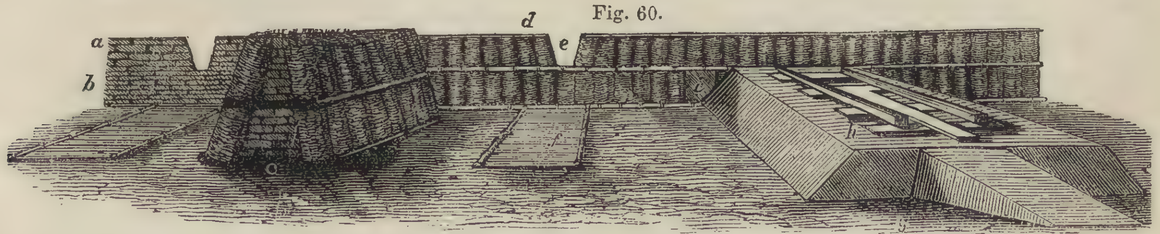


Fig. 53. Fascine. Fig. 54. Parapet reveted with Fascines (*a*, *b*, pickets and fascines used as anchors). Fig. 55. Fascine Choker. Fig. 56. Common Brushwood Gabion. Fig. 57. Plan and Method of Weaving Ditto. Fig. 58. Jones's Iron Band Gabion. Fig. 59. Musketry Parapet reveted with Gabions and Fascines. Fig. 60. Interior of Work, showing Splinter-proof Traverse, Platforms, and Revetment (*a*, sandbag revetment; *b*, fascine ditto; *c*, traverse; *d*, gabion revetment; *e*, embrasure; *f*, Pasley's gun platform; *g*, barbette for one gun; *h*, Colonel Clerk's platform; *i*, recess for powder or filled shells). Fig. 61. Enlarged View of Part of Platform at *h* in Fig. 60.

bours. The elongated shells of rifled artillery contain so much powder, and produce such powerful effects on bursting, that the necessity for numbers of traverses is greater than ever, and no work can be expected to continue its defence under their fire unless amply provided with them. A traverse which is intended to cover reverse fire is called a parados; and as these have frequently to be of considerable height, it is often impossible to allow sufficient interior space for them if made thick enough to really resist artillery. In these cases all that can be attempted is to construct them so as to screen the defenders from view.

Platforms.—In order to facilitate the running up of the guns after their recoil, and to enable them to be readily traversed or moved from one side to the other, platforms of wood, stone, or iron are constructed, on which are placed the carriages or slides on which the guns are mounted.

In permanent works where heavy guns are employed, they

Alderson's platform consists of a number of balks of timber of the same size. Ten of these are bolted together in pairs, forming five sleepers, which are sunk as before; and on them the remaining balks are laid at right angles, to form the floor. The peculiarity is that all the balks are alike, and are bolted together with wooden dowels. They are 15 feet long by 9 feet broad for guns, and 9 feet by 7 feet 6 inches for mortars.

Colonel Clerk's platform (*h*) consists of two long beams of inclined planes, with flanged edges, up which the gun-wheels recoil. These are supported on a front and rear beam or transom and two sleepers, all of which are let into the ground, with their upper surface flush with it. The trail of the gun rests on a plank projecting to the rear from the centre of the platform. The inclined planes are 17 feet long, and are about 1 foot wide; and the whole platform can be put together in one hour by four men.

SHIP-BUILDING.—VI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DIAGONAL RIDERS AND FILLINGS.

It has already been remarked that the transverse frames of wood ships taken alone are, from the positions they occupy, necessarily ineffective against longitudinal bending strains, and that the most common evidence of structural weakness in such ships is their "hogging" or arching upwards. Ship-builders have tried various plans for strengthening the framing, some of which have fallen into disuse, while others are still employed. Of the latter, the two most important are "diagonal riders" and "fillings," both of which are due to Sir Robert Seppings, who was Surveyor of the Navy early in this century. There had, we believe, been previous proposals to use diagonal strengthenings upon the frames of wood ships, and some of them had been actually tried in France, but to Seppings belongs the honour of having carried the system to a successful issue, and given it the form that it still retains.

Supposing a ship to be hogged, the ends must have drooped relatively to the middle, the upper parts must have been stretched, and the lower parts compressed. If, therefore, it were possible to strongly tie the ends of the ship to the middle, and to make the lower part capable of resisting great compressive strains, the resistance to hogging would be much increased. Seppings used diagonal riders for the former purpose and fillings for the latter. He illustrated the usefulness of the riders in a homely fashion, by referring to the rigidity of form given to an ordinary field-gate by means of the diagonal piece fitted from the upper angle at the side nearest the gate-post, to the opposite angle of the gate, and it will be easily seen that there is a great resemblance between the conditions of strain in the gate and those of the ship which tends to hog. The side of the gate farthest from the post tends to droop, and would droop if the gate were formed only of vertical and horizontal pieces, because these would be capable of offering but little resistance to a change of form from the rectangular to that of any other parallelogram. When the diagonal piece is fitted, however, it directly opposes any such change; for it will be obvious that in order that the rectangular form may be altered into that of any other parallelogram, the length of its diagonal must be changed. If two diagonals were fitted, still greater strength would of course be gained, because, while one resisted tension the other would resist compression.

Seppings carried this idea into practice, at first, by fitting strong and massive timbers, or "riders," inside the frames, and placing them at an inclination of 45°, with their heads sloping towards the centre of the ship, or "midship section," so that those in the fore-body were inclined in the opposite direction to those in the after-body. Besides these riders, complementary pieces, named "trusses," were fitted, also inclined at 45° to the vertical, but in the opposite direction to the riders adjacent to them; and in addition the internal strengthenings included thick longitudinal strakes of planking, overrunning and bolted to the riders and trusses. The plan was elaborately worked out, and it added much to the strength of ships, so that it attracted much attention, both in this country and abroad. It had, however, some disadvantages; unavoidable, perhaps, with wood, but still of consequence. The chief were the difficulty and expense of construction involved, and the great loss of space in the interior; but in spite of these objections, the plan continued in use in the Royal Navy for some years. The latter objection, loss of hold-space, induced Seppings to suggest that in small vessels, where such a loss would be most serious, iron riders might be used instead of wood, and it was not long before the advantages of the change led to the use of iron riders in larger vessels also. At present, timber riders are not used in British-built ships, but in American-built ships they have been occasionally used up to comparatively recent times, the abundance of timber in Canada and the United States probably being the chief cause of its continued employment.

The iron riders now in use are formed of long narrow plates (usually from 4 to 6 inches wide, and from ½ inch to 1 inch thick), placed diagonally, as shown by *r r* in the elevation in Fig. 15 (page 81). Their upper ends are generally situated near the height of one of the decks, and the lower ends near the first head, where the form of the frames amidships is getting flat. Like the timber riders they have replaced, they are so arranged as to have their upper ends inclined towards the midship section in both bodies; they are also usually allowed to cross one another for a short distance amidships. This arrangement is specially suited to iron riders, because it brings them into *tension* when the ship hogs, and they are capable of bearing considerable tensile strains, while they could not resist compressive strains. In some ships, however, the riders have been arranged on the opposite plan, with their heels pointing towards the midship section, and consequently they have not been nearly so useful as they should have been. If only one set of riders is fitted in each body, then they should be placed so as to resist hogging most efficiently; but if, as is sometimes the case, two sets, crossing each other at right angles, are fitted throughout the length, greater strength is undoubtedly given to the structure, and sagging as well as hogging strains are provided against. This duplicate arrangement is not often adopted, nor is it commonly required, but it has been carried out with advantage in many of the large wood ships of the Navy, and especially in some of the iron-clads. In the latter both sets of riders have been worked upon the frames, and bolted through them and the outside planking; but in the older wood ships it was common to have the second, or subordinate set, fitted inside the "ceiling" (or inner planking), and not to continue them above the height of the lower deck. A suggestion has been made, and we believe it has in a few cases been carried out in practice, that it would be well, while retaining the usual arrangement of a single set of riders at the bow and stern, to have a double set for a portion of the midship length. Such a plan would have the advantage of making the midship part strong against sagging as well as hogging strains, as it obviously ought to be, while it would leave the ends strong against hogging strains, to which they are especially subject.

The practice of the Government service is to fit the riders *inside* the timbers of the frame (as shown by *r r* in Fig. 15); that of the private trade is to fit them *outside*. Both plans have advantages and disadvantages. For facility in carrying on the work the Government plan is to be preferred, because the inside of a ship in frame is comparatively clear when the riders are fitted; whereas on the outside there are necessarily ribbands and harpins, to support the timbers in their proper positions, portions of which must be cut away or otherwise removed in order to fit the riders. On the other hand, the balance of advantage in point of strength lies with the private practice, although the balance may be small. A rider fitted outside and well secured at the ends, naturally lies close to the convex surface of the timbers; and when subjected to tensile strains is brought still closer, so that its friction on the timbers would probably be considerable, and the bolts fastening it to the timbers would be but little strained. A rider fitted inside, on the contrary, can only be held close to the concave surface of the timbers by the bolts, and its tendency to spring off from the timbers must be increased when it is subjected to tensile strains; so that under such circumstances the bolts have to bear nearly the whole strain, and receive little or no help from friction. In short, in the one case the timbers themselves mainly keep the rider to its curvature, in the other the bolts have to do the work, and enable the rider to develop its tensile strength. Whether fitted inside or outside, however, riders are important strengthenings to a wood ship, and they are particularly useful in assisting the outside planking to develop its strength. Besides this, they afford a good connection between the various parts of the framing, and indirectly add much to its transverse strength.

Sir Robert Seppings' system included also the use of "fillings" between the lower timbers of the frame. His object in proposing such an arrangement appears to have been twofold—viz., to add to the safety as well as the strength of ships. The sketches in Figs. 14, 15, 16 will illustrate the present mode of fitting these fillings in ships of the Navy. From Fig. 15 it will be seen that the fillings extend to a height rather greater than that of the third sirmark, and that they entirely fill the openings between the frames up to that height. The sectional view (Fig. 14) shows by a dotted line the shape of the filling, which gradually diminishes in its depth, or "moulding," as compared with the timber; this is done in order to form a "water-course." When fitted in place, the joints are carefully caulked, both inside and out; and it is this which adds to the safety of the ship, because injury to the bottom planking does not neces-

sarily cause the entry of water into the ship. In some cases this consideration has led to the extension of the height of the fillings as far as to the load-water line, but the practice is not common, nor does it seem a desirable one, seeing that injury to the planking is much more likely to take place below the height to which fillings are usually carried than above it. The gain in strength is not less important than that in safety; and it is due to the fact that the fillings render the lower part practically solid, and as incompressible as the material will permit it to be, so that the resistance to hogging strains is greatly increased. Without fillings the massive transverse framing would have no opportunity of developing its strength to resist compression, but with them the conditions are entirely altered. Hogging does, it is true, take place to some extent, even in wood ships with fillings and riders; but this may be explained by the fact that the longitudinal strength of the upper portions of such ships against *tensile* strains is deficient, rather than by the assumption that the lower part is incapable of bearing compression. Experience bears this out; working in the upper works of wood ships is far from being uncommon, but it is seldom one hears of any symptoms of weakness displaying themselves in wake of the fillings.

The use of fillings is not common in merchant ships, and the fact is rather to be regretted; but it probably is of minor importance now, seeing that only vessels of comparatively small size are likely to be built of wood. Against sagging strains fillings are not, of course, effective, nor do the lower timbers lend any material aid in resisting such strains, which would consequently have to be borne by the bottom planking, keel, keelson, etc. These are not the strains, however, which experience shows us to be the most injurious to wood ships; and while a ship with fillings is no worse off under these circumstances than one without, she has a great advantage when subjected to hogging strains.

The openings have in a few vessels been filled in very nearly from gunwale to keel, the framing being thus turned into a compact mass of timbering connected together by dowels and bolts. The weight of the framing is, of course, made much greater by this arrangement, and it is only had recourse to when very exceptional strength is required. In ordinary vessels partial fillings are required for special purposes in some parts—such as in wake of the channels, scuttles, etc.—but these do not add to the strength of the structure, and are not intended to do so.

OPTICAL INSTRUMENTS.—XVII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

Condensed Gas System.—Undoubtedly the usual arrangement of gas-bags, pressure-boards, and weights is a cumbrous one, though presenting advantages to the travelling lecturer in other ways; and though the water-pressure arrangements dispense with the impedimenta of weights, while the lecturer is travelling, they still present bulky and unwieldy packages. The Americans have lately advocated the method of condensing the gases in metal bottles, as presenting the advantages of compactness, extreme portability, and economy, *with the greatest amount of pressure attainable;* which, in other words, means security from the gases mixing, running back, and exploding—as *the weights* may be said *to be always on*—and also increased intensity in the light produced. Thus the gases may be kept at hand any length of time, and ever ready for use, which is not the case when they are stored in india-rubber bags. As regards comparative space occupied, while *a single* gas-bag of 6 cubic feet capacity within its pressure-boards would measure more than 36 by 24 by 24 inches when filled, and its weights 17 by 6 by 5 inches, *a pair* of bottles each of 6 cubic feet capacity would only occupy a space of 30 by 12 by 6 inches when packed in a stout travelling-case (Fig. 61). As regards comparative price, a stout gas-bag with pressure-boards and weights would cost £4 14s., while a bottle in case would only cost £3 3s.; and the bottle will not wear out, while the gas-bag must every now and then be replaced. As these bottles must be sent to the manufacturers to be pumped full, the cost of the generating apparatus is also saved. This leads us to the only drawback to the system: the pumping apparatus is costly, and requires great care in manipulation; in fact, the only danger in this system occurs at this stage of filling. But though this is a drawback to those who have to lecture night after night, the amateur would regard the saving him the trouble of making the gases as an advantage; as he has only to make a point of returning the bottles to be re-filled immediately after each exhibition to obviate this drawback, especially as he can obtain the gases cheaper than he can make them himself. To the photographer this form of apparatus presents great advantages for enlargements, being ever ready for use. But this system is not a new one, for it was employed twenty years ago by Mr. Adams, the well-known lecturer on astronomy and physics. These bottles consist of wrought-iron cylinders, 27 inches long by $4\frac{1}{2}$ inches in diameter, capped with most carefully-constructed valves worked by lever regulators, and are capable of holding 6 cubic feet of condensed gas. These are tested before sale to sixty atmospheres, or a pressure of 900 lb. on the square inch, and as the pumping pressure seldom exceeds twenty-five atmospheres, or less than half the test pressure, perfect immunity from danger is ensured. *À priori,* we should fancy that as the pressure is always on the decrease, the light would also be decreasing, unless the valves were under constant regulation; but practically this does not happen; for, if properly manipulated, we have not to alter the taps more frequently than with the gas-bag arrangement. Six cubic feet bottles will last two hours, though by careless working they might be used up in twenty minutes, or even in as many seconds.

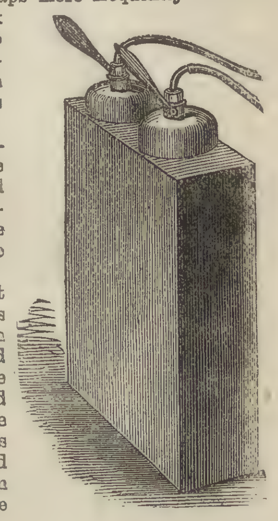


Fig. 61.

On connecting condensed gas-bottles with a lime-light jet, the taps of the jet should be turned full on, and never used, all adjustments being made direct by the lever-keys that regulate the valves.

Lime-Light Jets.—Lime-light jets are divided into two classes—"oxy-calcium jets," wherein the oxygen is completely isolated from the spirit or house-gas flame through which it is blown; and "oxy-hydrogen jets," where the gases are stowed in separate bags or other receptacles, and mixed in a tube just before passing from the nozzle. Oxy-calcium jets are again distinguished as "oxy-spirit-jets" or "oxy-house-gas jets."

Oxy-spirit Jets.—For "foreign service," or in country places when house-gas is not attainable, a good oxy-spirit jet is a most useful form of apparatus—in fact, the best form that can be recommended for such localities. The ordinary form is shown in Fig. 62: it consists of a "fountain-lamp" cistern capable of holding half a pint of methylated spirits of wine, S; the spirit is carried to the wick, W, by a tube terminating in a cylindrical wick-holder. The wick is ordinary lamp-cotton, about $2\frac{1}{4}$ inches in length, and about $\frac{1}{4}$-inch in diameter, passed through three tubes arranged triangle fashion (one wick next to the lime, two next the nozzle). When trimmed the cotton stands about $\frac{1}{4}$-inch above these tubes, and the entire wick is divided and bent back right and left, so as to leave a clear course for the oxygen to the lime, care being taken that no stray threads touch the nozzle or lime-cylinder. Beneath the spirit-tube runs another tube, O, that carries the oxygen gas from its receptacle to and through the centre of the spirit-flame, and on to the lime-cylinder, L, by an upward curve terminating in a blow-pipe nozzle, N.

The wick must stand at a proper height in relation to the fountain valve, or the spirit will overflow and cause accidents. Both careful construction and manipulation of this arrangement is necessary to prevent such a mishap.

In the *Journal of the Photographic Society* for December 18th, 1869, page 168, Dr. D. Van Monckhoven describes and figures a modification of the oxy-spirit jet, wherein the spirit is placed in a deep upright cylindrical spirit-lamp, but exception must be taken to the length of the spirit reservoir, as entailing too great a strain on the capillary powers of the cotton fibres, for the shorter the wick the fuller is it charged with spirit, and the liability for the wick to char is lessened.

M. Romain Talbot of Paris has arranged an oxy-spirit jet, so that the oxygen is projected through the centre of a cylindrical wick, nozzle and wick being concentric. By one arrangement the jet is projected on the lime in the usual angular direction. In another the oxygen jet shoots straight upwards through a wick formed of a bundle of fine wires, and the oxy-spirit flame is projected on a disc of soft lime placed at an angle to the perpendicular jet.

Convinced as I am of the value of the oxy-spirit jet for localities where house-gas is not attainable, and the making of pure hydrogen would be regarded as an insurmountable objection to the use of lime-light apparatus, I have modified the usual form of this jet, and I think it will be found with advantage. The points of construction are:—

1. A reservoir for the spirit that can be kept cool and cannot overflow.

2. A wick that gives a large compact flame.

3. A wick-holder that will keep the cotton wick so cool that it cannot char.

4. A support for the lime-cylinder that of necessity need not have an adjustment to and fro, if the lime-cylinder be turned to one gauge of a given diameter.

5. A large-bored blow-pipe nozzle, for which an adjustment to and fro in the flame is an advantage, set at such an angle that it makes the rays from the incandescent lime clear the tube that carries the nozzle, so that its image may not be projected on the screen by the condensers.

6. The means of adding more spirit, should it run short, without having to extinguish the burning wick or disturb the adjustment of jet in its lantern.

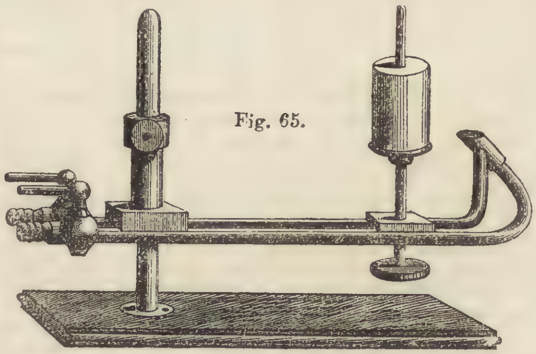


Fig. 65.

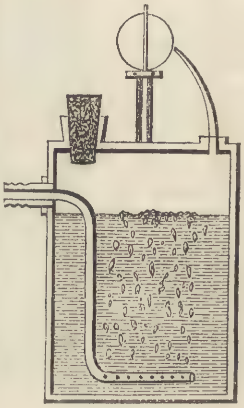


Fig. 68.

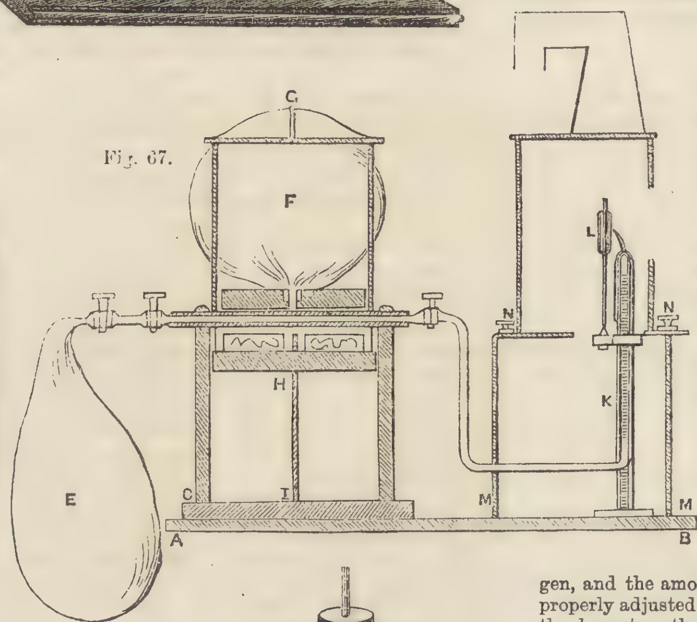


Fig. 67.

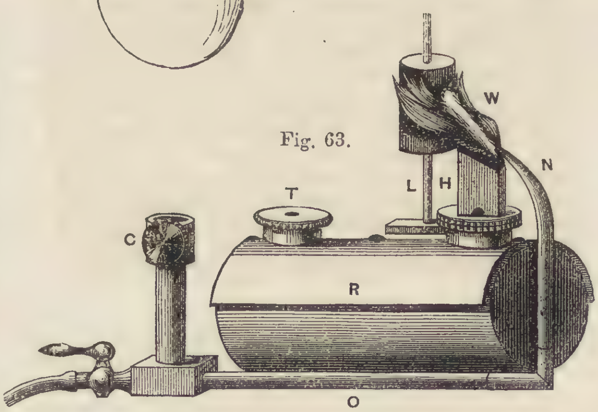


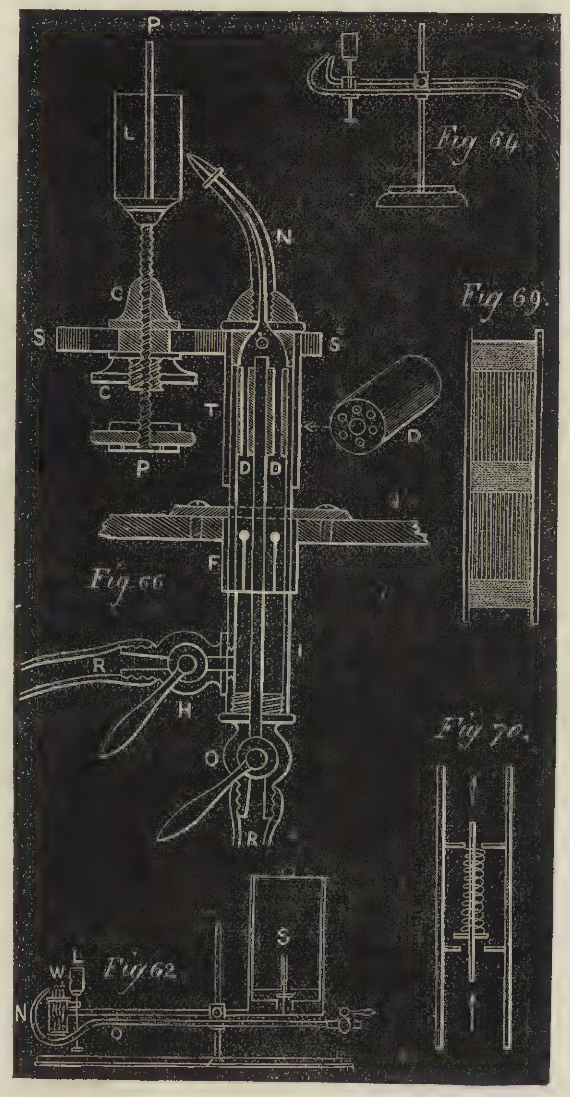
Fig. 63.

My oxy-spirit jet is shown in Fig. 63. It will be seen that the reservoir, R, is a horizontal cylinder (not upright as in Monckhoven's) somewhat resembling a steam-boiler in aspect, but is in fact a shallow spirit-lamp, wherein the arrangement of the wick and its holder is the important point of modification. Instead of being round and small, the wick, W, is long, wide, thick, flat and double, and is made of loosely plaited cotton, not cotton thread. The wick-holder, H, is made of thin sheet brass (to hold as little heat as possible), and is $\frac{3}{4}$-inch in the side by $\frac{1}{4}$-inch wide, and the top is cut obliquely to form an angle of 25°. This is fitted to the top of the spirit-lamp by a stout tubular fitting that allows of the wick being adjusted for height and direction. The wick is evenly trimmed to correspond with the angle of its holder, and is then divided and turned on each side to form a clear valley through which the oxygen is projected on to the lime. The reservoir is supported on a tube, O, that supplies oxygen to the flame, and this tube is attached to an adjusting clamp, C, that slides on a supporting rod. Into the end of the oxygen tube a blow-pipe nozzle of large bore, N, fits so that it is adjustable to the wick for height, insertion, and true intersection of the spirit-flame, and it is set at an angle corresponding with that of the wick. At the back of the reservoir is fitted a screw-capped tube, T, by which fresh spirit can be added while the lamp is burning.

A rotating lime-support, L, is attached to the tubular fitting into which the wick-holder slides. To keep the spirit cool, a current of air is admitted to the reservoir by holes in the screw-cap, T, and the wick-holder H. By the arrangement here described, the wick-holder will keep so cool that it can be easily handled while the wick is alight. When connected with a supply of oxygen, and the amount of gas is properly adjusted by means of the lever-tap, the spirit-flame is carried in a noiseless jet upon a soft lime-cylinder that soon yields a bright disc of light, and with full pressure the best light I have ever seen got out of an oxy-calcium jet. In conjunction with a portable metal gas-holder this fully meets the requirements of an Indian or colonial outfit, whether it be for photographic enlargement or lantern exhibitions.

Oxy-house Gas Jet.—In this arrangement the spirit is replaced by a house-gas flame supplied by a separate tube, as shown in Fig. 64. If thus disposed, it is better to flatten the end of the tube where the gas is ignited, and better still to make this terminal burner of a piece of tube of larger size; but the jet usually employed is arranged so that the house-gas envelops the oxygen nozzle to secure a more perfect combination of the two gases before they strike upon the lime-cylinder, being in fact a "Herapath's blow-pipe" modified for the lime light, as shown in Fig. 65. In both these arrangements it is impossible for either gas to pass from

one tube to the other, and form an explosive mixture, which has given rise to their being called "safety blow-through jets." The drawback to this form of jet is that the gases strike upon the lime with a roaring flame; but, on the other hand, house gas is cheaper than spirit, involves no lamp-filling and wick-trimming, and simply requires the tube set apart for the carburetted hydrogen to be connected by a vulcanised rubber tube with any house supply, such as the burner of a chandelier or gas bracket, and the other tube with an oxygen bag, gasometer, gas-holder, or condensed gas-bottle. Though great faith has been established in the minds of amateur lantern-workers as to the exceptional safety of this arrangement of jet, I must say that a form of oxy-house gas jet that is far neater, gives a better light (in consequence of the gases being perfectly mixed before they issue from the blow-pipe nozzle), and is free from the objectionable roar referred to, may be used with equal safety, if we consider the improbability of house-gas at the ordinary pressure of the main being driven into an oxygen bag when sufficiently weighted or *vice versa*. The arrangement I refer to is a modification of Professor Daniell's oxy-hydrogen blow-pipe, which, in its original form, was showy but cumbrous, being intended for lecture-table experiments, but as arranged for the lantern or for photographic enlargements, it is represented in Fig. 66. The difference between Herapath's and Daniell's jet is, that while the former has an *opened mouth nozzle*, as shown in Fig. 65, in the latter the gases are mixed in small volumes just before they issue from *a nozzle of small bore.* The arrangement is shown in section in Fig. 66. A stout tube, I, is fitted at its lower end with lever stop-cocks for hydrogen and oxygen, H and O. This tube slides through a spring flange, F, screwed to the floor of the lantern, etc., or it may be supported on a separate telescopic adjustable stand. Through the centre of this tube passes a fine pipe connected with the lower stop-cock, O, that conveys the oxygen to its upper end, where it is supported by a metal plug, D, that is drilled with holes to allow the passage of the hydrogen admitted by the stop-cock H. Over the tube, I, a tube, T, closely fits that carries the nozzle N, and lime-stage S S.



The lime-cylinder L is supported on the lime-pin P P, that can be adjusted upwards or downwards by means of a coarse screw, working through a clamp nut, C C, that slides to and fro in a slot cut in the arm S S, to allow of the lime being adjusted nearer to or further from the nozzle N. The taps H and O are respectively connected with the house supply, and a bag or other oxygen receptacle by the india-rubber tubes R, R. As in the previous arrangement, the hydrogen is first admitted and ignited at the point of the nozzle, and after it has warmed the lime, it is turned on full or nearly so, and the oxygen is then slowly admitted till the lime is rendered fully incandescent, the best effect being obtained when the house-gas is slightly in excess, as a preponderance of oxygen cools the lime and diminishes the full brilliancy obtainable by the proper mutual adjustment of the two gases. This form of jet may also be used for burning the gases under pressure, and is the arrangement in general use for "theatre lights."

Oxy-Hydrogen Jet.—In the early days of lime-light manipulation, both the gases were mixed in one bag or bladder, in the proportions of one quart of oxygen to two of hydrogen, and were then burnt in connection with a safety-jet. Fig. 67 shows such an arrangement, which has long been used and recommended by Woodward in his work on "Polarised Light." F represents the bladder of mixed gases placed in a descending pressure-frame, G H, the weights being placed on the shelf H below the bladder. This bladder can be replenished from a second E, fitted with transfer taps. The lime-jet, L, is not only fitted with a Gurney's water-chamber, but also a Hemming's wire gauze safety-tube, K, to be hereafter described.

At the present day few persons would care to commence any exhibition or lecture with less than 12 cubic feet of the gases, and each gas in separate bags with 1 cwt. on each bag, so as to be sure of sufficient supply, and a pressure that will ensure the full intensity of light obtainable by the "oxy-hydrogen" or "mixed gas jet;" and few practised manipulators now put faith in safety-jets, but rely entirely on the rules I have previously laid down, as to keeping the gas receptacles equally and always weighted during the time the apparatus is in action, and the gases burning. Nevertheless, it will be well to describe the various contrivances that have been recommended to ensure safety while using the oxy-hydrogen jet.

Gurney's water chamber is simply a small metallic bottle, to the top of which the nozzle and lime are attached. The *mixed* gases pass from their receptacle by a tube that turns downwards, to allow the gases to rise in bubbles through the entire depth of water with which the vessel is two-thirds filled, as shown in Fig. 68. Should the ignited gases by any accident recede, it was supposed that the water would cut off the delivery-tube, and any explosion would be confined to the small portions of gas above the water; but I have heard of a case where the rising bubbles formed a train of explosive gas and passed to the delivery-tube.

Hemming's safety tube (Fig. 69) is formed of an alternate series of horizontal layers of fine meshed wire gauze, and vertical bundles of wires, through which the gases are driven, and it was supposed would retard and extinguish an explosive mixture, if there were any tendency to recede. But hydrogen under pressure can be driven back into a bladder partially filled with oxygen placed under weaker pressure, and that if a light be applied to the free end of the wired tube, on the weight being removed from the bladder, a "suck back," as it is termed, will occur, and an explosion will follow.

Taylor's safety valves are of two kinds: one, a light flap valve hanging by a hinge, which may at once be disposed of, as not being reliable unless *accurately levelled*, or inclined so that the flap should lay upon the aperture that admits the gas. The

second is a more practical and reliable form, shown in Fig. 70. This is a spring valve that can be fitted between a pendant portion of the india-rubber delivering-tubes, and allows the flow of gas under pressure to pass in *one direction only;* should a greater pressure be set up in the wrong direction, the spring comes into play, and the valve is tightly closed.

The so-called safety-jets, having valves, bundles of wires intersected by wire gauzes, and even Gurney's water-chamber, are, I believe, snares to careless operators, for if the pressure on the bags be unequal, the gas on which there is the greatest pressure being unable to escape in sufficient quantity from the bore in the nozzle of the jet, gradually forces back the gas under lesser pressure, an explosive mixture is gradually formed in the bag, and if the smaller weight is accidentally or carelessly removed, an explosion must follow.

SILK CULTURE.—III.

By Alexander Wallace, M.D.

TREATMENT OF GROWING WORMS—TABULAR PROGRAMMES OF THE EDUCATION OF EGGS, ETC.

As time progresses and the worms get larger, the temperature should also increase, and the hygrometer show a dryer atmosphere. As much ventilation should be given as possible, avoiding draughts and currents of cold air. Food must also be given in larger quantities, and at more frequent intervals. In the 3rd age five feeds a day will often be necessary, and in the 4th age from six to eight feeds may be given. It will not now be necessary to cut the leaf so fine. In many *magnaneries* the leaf is given whole after the 3rd age; but by using the mulberry leaf-cutter economy of leaf is obtained even to the last, as well as economy of labour. Regularity in the hours of feeding is essential. During the 1st age 7 square feet are required for every ounce of worms; in the 2nd age, 14; in the 3rd age, 34; in the 4th age 82; and in the last age, 183 square feet must be allowed. It follows, therefore, that in calculating how many worms may be educated in a given space, regard must be had to the last age, when the greatest space is required; but, as I have before observed, it is wise to provide a much larger supply of eggs than the number actually to be reared, so as to provide against losses that may ensue during the education. One ounce of eggs will give at a rough computation about 40,000 worms; these should consume from 1,200 to 1,600 lb. weight of leaves, and should produce at least 45 lb. of cocoons. During the education there will be carted away in refuse from the trays 745 lb. 8 oz., of which 155 lb. 8 oz. is excrement, the rest stalks, fruit, and unconsumed food. Hence it appears that the worms would consume about 770 lb. of leaf, which would suffice, if all the worms lived, to produce 120 lb. of cocoons; hence the deduction that 16½ lb. of pure leaf is sufficient to produce 1 lb. of cocoons, provided none of it be wasted.

Subjoined is Count Dandolo's programme of the education of 5 oz. of eggs:—

1814. Days of rearing.	Months.	Sorted leaves.			Internal temp. at 5 a.m.	External temp. (westerly) at 5 a.m.	Hygrometer of M. Bellani.	Weather.
1st age	May.		lb.	oz.	Deg.	Degrees.	Deg.	
Day 1	23		2	2	73-71	53	...	Rain.
„ 2	24		3	9	71	48	...	Rain & storm.
„ 3	25		4	9	71-69	44	...	Rain & sun.
„ 4	26		8	0	69	46	...	Clouds & sun.
„ 5	27		7	9	71	50	...	Clouds.
„ 6	28		4	3	71½	55	...	Rain.
			30	0				
2nd age								
Day 7	29	Small branches and leaves.	8	10	71	48	68	Rain.
„ 8	30		16	8	71	53	70	Fog, sun.
„ 9	31		23	6	68	57	64	Ditto.
„ 10	June 1		22	8	68	57	66	Rain.
„ 11	2		10	8	68	64	66	Rain & sun.
„ 12	3		1	8	69	62	70	Clouds.
			83	0				
3rd age	June		lb.	oz.	Deg.	Degrees.	Deg.	
Day 13	4	Small branches and leaves.	21	0	69	55	68	Rain & sun.
„ 14	5		45	0	68	55	69	Clouds & sun.
„ 15	6		60	0	69	62	70	Rain & sun.
„ 16	7		90	0	69	57	75	Rain.
„ 17	8		75	0	69	56	74	„
„ 18	9		30	0	69	53	79	Rain & sun.
„ 19	10		3	0	69	57	78	„
			324	0				
4th age								
Day 20	11	Small branches and leaves.	75	0	69	57	76	Rain & sun.
„ 21	12		127	8	69	64	75	Clouds & sun.
„ 22	13		180	0	68	65	71	Fine.
„ 23	14		195	0	66	62	74	Clouds & sun.
„ 24	15		249	0	66	65	75	Sun & rain.
„ 25	16		105	0	68	66	72	„
„ 26	17		7	8	69	57	70	Fine.
			939	0				
5th age								
Day 27	18	Small branches and leaves.	180	0	68	60	72	Fine.
„ 28	19		270	0	68	62	73	Rain & sun.
„ 29	20		360	0	68	57	73	„
„ 30	21		465	0	66	59	75	Rain.
„ 31	22		540	0	68	57	73	Clouds & rain.
„ 32	23		675	0	68	53	72	Rain & sun.
„ 33	24		825	0	68	55	74	„
„ 34	25		975	0	68	53	74	„
„ 35	26		750	0	69	55	73	„
„ 36	27		420	0	69	55	73	Clouds & rain.
„ 37	28		270	0	69	50	72	Rain & sun.
			5730	0				

SORTED LEAVES.

5th age	5730 lb.	
4th age	939 „	
3rd age	324 „	
2nd age	83 „	
1st age	30 „	
Total sorted leaves	7106	
Add	1024	refuse leaves, loss from evaporation, etc.
	8130 lb.	

Or 8,630 lb. of leaf picked from the tree to feed 5 oz. of eggs, or 1,626 lb. of leaf for 1 oz. of eggs.

OBSERVATIONS.

First Age.—The silkworms on some tables or hurdles roused sooner than others. By reason of the exterior cold, the temperature of some parts was a degree and a half below other parts, although the whole was well closed, and lined to keep out the cold. This degree of cold was on the side of the apertures and lower rows of tray hurdles.

Second Age.—The silkworms became torpid, and roused with more regularity, and at less distant periods than in the first age.

Third Age.—All proceeded with regularity. There were twenty-four pounds more of mulberry-leaf consumed this year than in the preceding. There was less refuse picked from the leaves this year, consequently the average quantity of leaf must have been nearly the same in both years.

Fourth Age.—Two days were employed in cleaning the wickers, because the silkworms that were placed in the coldest part of the laboratory became torpid, and roused a whole day later than the others. Thirty pounds more of sorted leaves were consumed than in the previous year, but there was less refuse. The progress of the fourth age was tolerably regular.

Fifth Age.—The cold and variableness of the weather under these last shown days of the season were remarkable. The silkworms continue to prosper. But as the nights were very cold, an even temperature throughout every part of the laboratory could never be obtained. Fires were lighted in the stoves, and thick wood was burnt in the grates to maintain the necessary temperature. There were 84 lb. more of leaves consumed than in the previous year. The refuse of the leaves and the weight of dung were less than in the previous year. There were fewer mulberries on the branches, and even these were lighter than in 1813. There were obtained 6 lb. more of cocoons. Some wicker hurdles required a little leaf on 29th of June, the thirty-

eighth day of the rearing of the silkworms, and they received that which had not been consumed the preceding day—1,626 lb. of leaves per ounce of eggs. The silkworms of 5 oz. of eggs, having consumed 8,130 lb. of leaves, produced 601 lb. of choice cocoons, and 4 lb. 8 oz. of coarse floss; giving, therefore, about 20 lb. of leaves consumed for $1\frac{1}{2}$ lb. of cocoons.

In order to show what may be done in this country, I annex the table of temperature as observed in my small *magnaneries* at Colchester, in 1871; with a description of the room, and the dates of my education. The hygrometer used was obtained from Negretti and Zambra, called a damp-detector, small, portable, and sufficiently accurate for the purpose. About 25° seemed the medium point at which the worms may be considered in a safe atmosphere. Should the indicator not reach that point, it became necessary, either by means of extra ventilation or dry warmth from gas-stove, to renovate the atmosphere of the *magnanerie*. A good blaze in the Arnott's stove, from straw, wood, or fresh coal, will often accelerate ventilation, and freshen up the room. When there is a deficiency of ventilation, or an excess of moisture in the air, the worms are sluggish, lose their appetite, and rise very slowly. Vigorous, hungry worms, that consume leaf largely, are sure to do well.

Date.	Minimum during night.	Temperature at				Hygro-meter.	Remarks.
		9 a.m.	12	3 p.m	6 p.m.		
June 4	$57\frac{1}{2}$°	61°	62°	63°	65°	28°	Worms begin to hatch out.
„ 5	60	64	65	64	64	30-26	
„ 6	63	62	63	65	65	28-25	
„ 7	58	61	63	62	61	27-25	No sun, no gas-stove.
„ 8	60	62	64	65	62	27	Gas-stove at night.
„ 9	62	65	70	68	68	27	Gas-stove during day.
„ 10	66	70	70	70	70	26-25	Ventilators open for first time. No gas-stove.
„ 11	62	66	68	70	66	27	No gas-stove.
„ 12	62	68	75	75	74	27	Gas-stove, no fire.
„ 13	64	70	70	70	70	25	„ „ „
„ 14	70	70	72	74	74	28	„ „ „
„ 15	70	72	73	75	75	30	„ „ „
„ 16	69	72	75	72	70	30	Fire for the first time in Arnott's stove.
„ 17	69	73	71	69	69	30	Dull, muggy weather.
„ 18	67	71	72	72	70	30	„ „ „
„ 19	65	70	73	70	70	29	
„ 20	67	72	70	72	75	29	
„ 21	66	71	77	75	73	28	
„ 22	68	70	74	70	73	25	
„ 23	66	71	72	70	70	26	Cold north wind.
„ 24	65	70	70	69	73	26	Very cold, no sunshine
„ 25	68	67	67	72	70	24	Cold.
„ 26	65	70	71	73	72	24-22	
„ 27	63	70	73	73	75	23-22	Warmer.
„ 28	65	68	73	70	70	25-26	
„ 29	70	73	72	71	71	25	Gas-stove at night.
„ 30	67	70	71	72	71	26	
July 1	64	70	71	71	71	25	
„ 2	65	70	72	70	71	27	Showery.
„ 3	65	70	73	75	73	28	„
„ 4	66	70	66	70	70	28	
„ 5	69	71	72	71	70	26	Thunder.
„ 6	69	71	70	70	70	26	
„ 7	74	72	75	75	75	26	Gas-stove at night.
„ 8	69	73	75	74	71	28	
„ 9	67	72	75	75	72	27-25	First cocoons began.
„ 10	67	70	72	73	70	25-24	
„ 11	66	71	72	70	70	26	
„ 12	64	70	72	73	70	25	
„ 13	72	74	71	73	73	25-26	
„ 14	71	72	76	75	70	27	
„ 15	73	75	75	77	75	27	
„ 16	76	75	75	75	75	26	
„ 17	71	72	76	77	75	26	
„ 18	72	71	75	75	74	25	Gas-stove at night.
„ 19	68	72	75	76	74	25	
„ 20	71	72	71	72	71	25	
„ 21	69	71	73	76	73	24-25-23	
„ 22	69	71	72	74	73	24	
„ 23	66	71	73	74	72	24	
„ 24	66	71	72	73	72	23	
„ 25	66	71	74	74	72	24	
„ 26	66	72	74	74	72	23	
„ 27	68°	71°	73°	76°	76°	22°	
„ 28	68	71	75	75	73	22	Moths emerging.
„ 29	68	71	75	74	72	23	
„ 30	67	71	71	72	70	23	
„ 31	63	71	73	74	71	23	
Aug. 1	67	71	73	75	73	22	Moths coupling and depositing eggs.
„ 2	66	71	75	76	74	21	
„ 3	67	71	75	76	74	21	
„ 4	70	73	73	70	69	22	
„ 5	64	70	72	75	73	21	

I tried three samples of eggs for my experiment:—No. 1, a small sample, about $\frac{1}{4}$ oz. (yellow), from Japan, brought by a friend, probably "bivoltine;" No. 2, a second sample ($\frac{1}{4}$ oz., from Japan, of a noted (yellow) race, imported; No. 3, 1 oz. of a (yellow) Japanese race, reproduced in 1870 in Europe.

	Hatched out.	First Moult.	Second Moult.	Third Moult.	Fourth Moult.	Spinning.	Life of the worm lasted.
1.	June 6	June 14	June 21	June 28	July 2	July 11	33 days.
2.	„ 5	„ 13	„ 21	July 2	„ 10	„ 20	45 „
3.	„ 4	„ 12	„ 20	„ 28	„ 8	„ 18	44 „

My *magnanerie* is on the ground floor, with no room above it, 10 feet 9 inches high, about 20 feet long, 15 feet broad, containing about 3,100 cubic feet of space. M. Taurigna, in his manual, states that about 2,100 cubic feet are required for each ounce of eggs. "Une magnanerie ou chambre destinée à une éducation de cinq onces doit avoir au moins 72 mètres* de surface, c'est à dire, 12 mètres de longueur, et 6 de largeur; sa hauteur doit être au moins de 4 mètres, ce qui produits un vide de 288 mètres cubes, soit 57 mètres cubes par once de 31 grammes" (our English ounce).

The only window in the *magnanerie* faces west; a skylight facing north lights the east end of the room: there are three doors, on the eastern, western, and southern sides respectively. The southern wall is scarcely at all exposed to the sun; but the roof, facing south and north, is scarcely if ever shaded; on the southern side is a small room, and outside that a greenhouse, so that a constant current of air on sunny days, warmed by the glass house, permeates the *magnanerie*. For ventilation, there are three openings in the ceiling, about 12 inches square, into the space under roof, closed with perforated zinc; a ventilating brick is over the west window, and two other openings cut in the north wall just beneath the level of the ceiling. These, as also the perforated brick opening, are closed at will by wooden shutters; the skylight is also made to open. But the most important ventilating apparatus is an Arnott's stove, with the addition of an opening made just below the ceiling into the chimney, fitted with an Arnott's ventilator, which may be closed at will. This aperture opens into an iron pipe 4 feet long, running upwards inside the chimney, and with a cap on the top to prevent the downfall of soot. The warmth from the fire below creates in this 4 feet pipe a constant upward draught of air, which must be supplied from the room; thus the upper strata of air are continually drawn off. The Arnott's stove below is set in fire-brick, and constructed with a coal-box beneath, which supplied fuel for nine hours without requiring further attention. The floor of the coal-box was elevated from below by a lever and ratchet apparatus, and thus coal was lifted up from below as required for further use. This box was filled every night at six p.m., and the fire relaid and lighted. Being made up again at ten, it kept alight all night. In the morning, however dull and black the mass appeared, by means of elevating the coal below and drawing the blower down in front, a brisk blaze was soon induced, and in half an hour a very hot fire; the fire-brick when once hot remained so for at least twenty-four hours. Hence there was maintained throughout the twenty-four hours, and especially at night, perpetual ventilation, not merely as regards

* A mètre is equal to 40 inches as nearly as possible.

the lower strata of air, but also, by means of the pipe in the chimney, the upper strata were gently and imperceptibly drawn off; at the same time great heat was given off by the fire-brick, and thus a most efficient apparatus was brought into action to counteract the atmospheric difficulties of our English climate, and with perfect success, as evidenced by the records of the temperatures in 1871. Another warming apparatus at the farthest end of the room was occasionally used—a Mussett's gas-boiler and horizontal coil of four pipes 3 feet long, was placed at the southern side of the room; two atmospheric burners heated the boiler, and the gas fumes were carried off by means of a close-fitting iron case and pipe, carried over and across the room to the chimney. Half an hour after the gas was lighted the water in the pipes became so hot that the hand could not be retained on them; the gas was then lowered, and the water kept about boiling temperature. In this way, at an economical rate, extra heat was occasionally supplied, especially at night and during the cold sunless days, and on some occasions when the Arnott's stove was not in use. By means of this apparatus the temperatures were kept very equable, and ventilation thoroughly attended to. It will be noted that, notwithstanding the cold and wet season, especially during the month of June, the temperatures were kept at an equable and moderate rate, and the hydrometer at a fair level, and this in one of the coldest and most inclement seasons we have experienced. After the experience of the year, the climate of England need not be cited as offering any difficulties to the maintaining in our *magnaneries* the necessary atmospheric and hygrometric conditions for the culture of the mulberry silkworm.

As the worms get larger, their refuse gets heavier and more bulky, and it is well to change them oftener, at least twice a week, and in the last age every day if possible. I prefer to use nets for the first four ages, but for the last age the *papier filets*, chiefly because nets will not sustain the great weight of worms at that age when lifted off in cleaning the trays without stretching very much, and this disarranges the worms. During the first three ages, in cleaning, nets may be put over the trays, and removed by one person by the aid of two sticks with a nail at the end, one in each hand; the nail being inserted in a mesh at one corner of the net is twisted round, this retains the farther corner; the nearer corner of the net is held in the same hand as the stick. Thus one side of the net is held tight by means of the stick in each hand, and is thus easily lifted off and replaced; but in the last two ages it becomes desirable to have extra help in changing the nets, and the *papier filets* are more easily handled. It is at this point that the table in the centre of the room becomes of considerable use. The operation of cleaning is as follows:—A fresh *papier filet* having been placed on a tray early in the morning, is fed over; at noon, the whole (including the brown paper below) is removed in one operation and placed on the floor alongside the table, whereon another sheet of brown paper has been placed ready. The upper *papier filet* is now removed with the worms, and placed on the table, and thence returned with the sheet of brown paper to the tray; the old bed is then placed on the table, looked over and cleaned, the refuse being thrown away, and the *papier filet* hung out to air till the next day, when it is used again. In this way tray after tray is cleaned rapidly and easily; and since it takes less time to adjust a *papier* over the tray, owing to its stiffness, than a net, it cannot be denied that the *papier filets* have an advantage over the nets in the late stages. As spinning-time approaches, their excretions become moister and enormous in quantity, and there is therefore greater exhalation from the worms and from their bed; they eat enormously. Great cleanliness and abundant ventilation are therefore necessary. At last they become of a yellowish translucent colour, their heads seem very small, they stop feeding, and as their intestinal canal empties so the lower segments of the body contract, and the ultimate segments get narrower and tail-like. They wander about, approach the edge of the tray, and hold up their heads as if looking for something. Then is the time to set up the bushes for the cocoon to be spun in, and the labour of the last moult is now to be critically tested.

Fig. 4.—CATERPILLAR, COCOON, CHRYSALIS AND MOTH OF THE BOMBYX POLYPHEMUS.

CIVIL ENGINEERING.—XIV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS.

The harbour at Aberdeen as left by Smeaton was capable of still further improvement by a judicious extension of breakwaters and piers. In 1810 Telford was employed to carry out the object. He found the south or catch-pier, which Smeaton had erected, destroyed, and as this was an essential structure, Telford constructed another of a more substantial character, of cut granite, having a talus or slope seawards of 1 in 5. This was followed by an extension of the north pier to a distance of 300 feet in advance of the point Smeaton had carried it to, and this was found so beneficial to the harbour, that it was subsequently extended 565 feet further. The extremity of this immense projection, stretching out upwards of 2,000 feet in a north-easterly direction into the German Ocean, has a slope of 5 to 1, and stands the fury of the prevailing winds well. The mode of constructing this breakwater was original and very successful. The bottom is a loose sand and gravel, and in order to consolidate the work under low water, large stones were dropped from lighters, the interstices being filled in with smaller, until it was brought near the level of low water, at which level the ashlar work commenced. This ashlar work is not laid as usual, horizontally, but at an angle of 45°, inclining backwards, by which arrangement it was better able to withstand the action of the sea during the progress of the work.

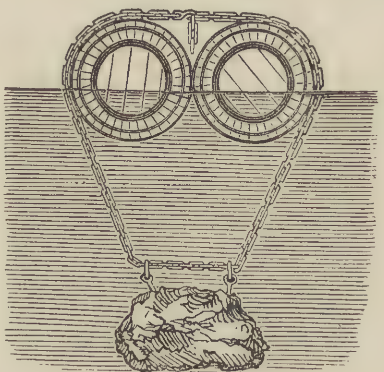


Fig. 33.

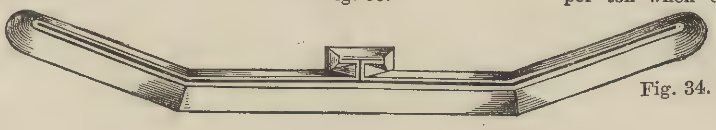


Fig. 34.

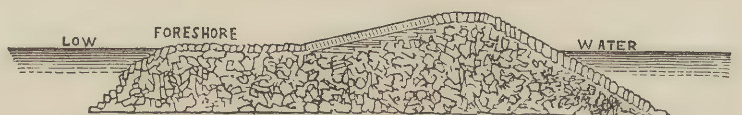


Fig. 35.

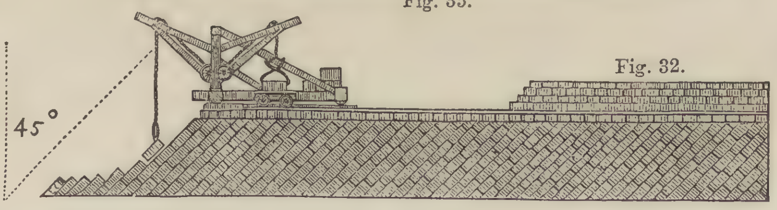


Fig. 32.

Fig. 32 shows a longitudinal section of the pier, and the position of the ashlar stones.

The stones employed in the foundation are of a gneiss formation, and being difficult to dress, the local masons call them "heathens." Some of these weighed from five to thirty tons, and were slung between the bows of two lighters having counter-weights at the stern; by this means they were floated to the pier-head, and deposited in their proper position. A railway was laid down along the pier, with a double-headed crane at the end moving on a framing of timber resting on rollers. This railway advanced with the work, and greatly facilitated its progress.

There are many towns upon the east coast of Scotland which from their exposed position require to be protected by piers. These piers, from the character they sustain, and the object with which they are erected, partake essentially of the nature of breakwaters. Peterhead possesses an important breakwater of this kind. The granite in the neighbourhood, called locally "Pacey whin," is an admirable material for these structures. It is excessively hard, and cannot be worked in the ordinary manner, but the masons who use it are aware of a peculiarity it possesses, and avail themselves of it. The stone has a natural cleavage, or "greet" as it is termed, the position of which those accustomed to it readily ascertain, seldom mistaking it. They then draw a line in the direction of the "greet," and sink a row of holes along it with a heavy double-ended blunt-pointed hammer, the points being highly tempered. These holes are then united by a groove into which they place steel wedges, striking the wedges in succession with a heavy hammer along the whole line, till the stone splits asunder, the fissure being nearly as straight as a saw-cut, but not so smooth.

An excellent breakwater pier exists at Frazerburgh, on the east coast of Scotland. It has three bends; the first runs north-east for 272 feet; the second turns a little to the south of east for 440 feet, and from thence returns almost due south for 100 feet. This pier is 33 feet 7 inches thick at the top, not reckoning the parapet wall, which is 4·5 feet thick in addition. It stands 20·5 feet above low-water mark, and slopes considerably on the sea face. Towards the harbour the face is curved.

In the construction of the piers at Pulteney Town, in Caithness, Telford made use of casks made of fir, in order to float the stones employed in constructing the foundations. Some of the stones are of immense size and weight, varying in length from 3 to 20 feet, and from 8 to 15 inches in thickness, their breadth being about 3 feet 8 inches. The casks weighed about 25 cwt. each, and displaced about 445 cubic feet of water, so that two of these casks would support $34\frac{1}{2}$ tons of stone. Four casks were made use of, and they were sometimes employed to assist in floating the vessels laden with stone. Owing to the limited depth of water in the harbour, the stone-laden vessels would not always float in it, not even at ordinary high tide; four of these casks placed two on each side of the vessel, and connected with chains passing under the keel, exercised a lift sufficient to enable them to enter and deposit their burden. The casks did not cost more than £8 each, and by their aid the stones, which had to be brought three miles, cost only 1s. 6d. per ton when deposited. Some of the stones employed were brought from positions under low-water mark. Holes were then bored in the upper face of the stone, and an iron shank, 2 inches in diameter at the bottom, and tapering upwards to $1\frac{1}{4}$ inch at the top, was inserted and a wedge driven in. The top of the shank was furnished with a ring, to which was attached the chain connected with the cask, the chain being tight at low water; at the flow of the tide, the stone was floated and brought to its destination. The casks employed were strutted inside similarly to the spokes of a wheel, and strongly hooped round on the outside. The casks were employed in pairs in floating the stones, and two of the shanks we have described, which partook of the character of a *lewis*, were inserted in each stone; by this ingenious disposition of the floating power, the stone was prevented from swerving. This arrangement is shown in Fig. 33.

A very fine pier of modern construction exists at Holyhead, and protects the harbour from the north and west gales. The northern pier is upwards of 1,300 yards long, and 270 feet broad at the base; the slope towards the sea is 5 to 1; the breadth at the top is 8 feet. The end of the pier stands 47 feet above low-water mark, and widens to 164 feet. All the masonry is constructed of granite found in the neighbourhood.

In many parts of the coast, the sand lies very compact and firm when not subjected to the action of the sea. A durable and inexpensive plan of raising a breakwater or pier upon this kind of bottom is to drop a large quantity of rough stones so as to form an artificial rock or base for the superstructure, in the proper direction, and of ample width, upon the sand. These

stones sink by degrees into the soil, and others following upon their top will eventually cause the whole mass to find a solid bearing upon the sub-stratum. Of course more material is employed than would be the case if the pier were erected upon a regular base; but as the stones are undressed, and no timber employed, the cost is less than if piles were made use of.

Plymouth Breakwater is one of the finest works of marine engineering upon our coasts. The Sound is a fine sheet of water more than three miles wide, and possessing an area of about 4,000 acres, with a depth of water equal in some parts to 60 feet at low spring-tides. Nothing was wanting, in fact, to render this space of water the finest harbour possible, except the position of the entrance, which is almost due south, and lay exposed to the fury of the south and south-west winds. To obviate this only defect, after many plans were discussed and rejected, it was resolved to carry out the plan proposed by Rennie, and in 1811 the necessary authority was issued by the Government to commence the works. Mr. Rennie's proposition was to form a breakwater across the middle channel by depositing a quantity of large blocks of rubble into the sea; the blocks being from two to twelve tons each, were to be allowed to find their own base, and in this manner the sub-structure was to be raised. He proposed that the breakwater should be 5,100 feet long, the central portion, 3,000 feet long, standing due east and west, with a wing at each end 1,050 feet long, inclined inwards at an angle of 160°. This was the plan which was carried out. Fig. 34 represents a plan of the breakwater.

The stone employed is principally limestone taken out of quarries which were purchased from the Duke of Bedford at Oreston. Considerable difficulty was experienced in finding contractors willing to undertake the work, owing to its novelty, except at prices so high that it was determined to contract only for a portion of the work at a time. The price paid for taking and depositing the first portion of the rubble was 2s. 9d. per ton, but afterwards, when the contractors became more accustomed to the work, this was reduced to 1s. per ton. The manner in which the stone was transported from the quarries to the breakwater was as follows:—Vessels of about 60 tons burden were employed having two lines of rails laid along them, parallel to each other, the ends near the stern being raised on an inclined plane to prevent the trucks from running too far. The blocks of stone were placed upon trucks which were then run upon the parallel lines of rail. After the vessel arrived at its destination, the trucks were discharged by tilting them up by means of windlasses fixed to the deck. The stone was deposited direct into the sea from the trucks. Steam-tugs were employed to tow the vessels in order to economise time. At every thirty feet along the intended line of the breakwater, buoys were laid down, to which the laden vessels were attached whilst discharging their cargo. A careful account of the quantity deposited, and the level to which it rose, was kept, so that the actual state of the work was known at all times.

The process of depositing the rubble proceeded almost uninterruptedly for two years, when portions of the work began to be visible at low water, and very shortly after, a continuous line of about 720 yards appeared. The good effects of this ridge soon began to be manifest, and long before the breakwater assumed its ultimate dimensions it was found of the greatest service in sheltering vessels from the south-westerly gales. The Emperor Napoleon I., who entered the harbour on board the *Bellerophon* during the progress of the work, was greatly struck with its utility.

The stone was raised in large blocks, many weighing fully ten tons, and in depositing them care was taken that the greater number were deposited upon the outer slope. After the larger stones had been lowered to form a base, a smaller class of stones, rubbish from the quarry, and lime screenings were thrown in. These effectually filled up the cavities and interstices, and the whole finding their position by the action of the sea, the mass as it advanced became wedged together. The outer slope, which is about 5 to 1 vertical, was formed by the sea during a storm in 1824. Previous to this storm only the lower portion was laid down with this slope, the upper part, contrary to the engineer's wishes, having been carried up with a talus of 3 to 1 vertical. The effect of the storm, however, fully proved the correctness of Mr. Rennie's views, and consequently the seaward slope remains at 5 to 1 to the present day.

As soon as sufficient time had elapsed to enable the lower portion of the work to become consolidated, the seaward slope down to the foreshore was cased with regular courses of masonry, and by the aid of the diving-bell these courses were dowelled, joggled, dovetailed, and cramped together. The three lower courses were all granite, laid horizontally, dovetailed, lewised, and bolted together. The mortar employed consisted of one part of pozzuolana, and one of Aberthaw lime, mixed with two parts of fine sharp fresh-water sand, the whole being well worked together in a mill, with as little water as possible. This anhydrous mortar set very quickly when used. Roman cement was employed for the outer joints, and for some distance within.

Towards the end of 1815, 615,000 tons of stone had been deposited, sufficient to raise 1,100 yards of the work above low spring-tides. Mr. Rennie's first intention was to raise the breakwater 10 feet above this point, but when the practical utility of the work became so evident, it was resolved to raise the whole structure 10 feet higher. The finishing of the work between the lines of high and low water required extreme care, and involved more expensive work, as it is known that the waves exercise their greatest force between these parallels. The work, however, proceeded with great speed, on some days as much as 1,000 tons and upwards being deposited; and by the end of 1816, 300 yards of the western portion of the breakwater had been raised to the full height of two feet above high water. The work was only fully completed in 1841. The slopes are paved with blocks of the largest stone, firmly united.

It is computed that 3,369,261 tons of stone were used in the construction of the breakwater from 1812 to March, 1841, the cost of the whole work being nearly £1,500,000. Upon a comparison between the quantity of stone deposited and the cubical contents of the entire mass, it is found that, owing to the employment of large blocks of stone, the unfilled interstices occupy about 37 per cent. of the whole. The dimensions of the section, shown in Fig. 35, are as follow:—The exterior slope, below the line of low water, is from 3 to 4 feet horizontal to 1 perpendicular; and from the low-water line upwards, it is 5 to 1. The inner slope is 2 horizontal to 1 vertical, from the base to the top, which stands 2 feet above high-water spring-tides. The width of this portion is 45 feet, the centre forming a ridge 1 foot higher. Beyond the slope towards the sea is an additional foreshore, varying in width from 30 feet at the east end of the breakwater, to 50 feet in the centre, and 70 feet at the west end. This foreshore rises about 5 feet above the level of low water, and serves to break the violence of the waves before they arrive at the principal work beyond.

The western end of the breakwater enlarges into a head 390 feet diameter at low-water level, and diminishes to 75 feet at the top. Upon this head is fixed a lighthouse 14 feet diameter, built of granite, and divided into floors. The centre of the light is 55 feet above the top of the breakwater. The lantern is 12 feet diameter, and 7 feet 6 inches high, and is furnished with a fixed dioptric light with mirrors. The lower courses of the column are secured with slate dowels, placed both vertically and horizontally. The ends of the stone are also dovetailed, and secured in their places by plugs of copper, and by wedges driven into the lower stone.

One of the earliest examples in this country of a breakwater formed of *pierre perdu*, as it is termed by the French—that is, of stones deposited in uneven masses—is to be seen at Lyme Regis upon the Dorsetshire coast. The stones forming this breakwater are so rough and large, and the interstices between them so considerable, that the water flows freely in and out; the violence of the surge is, however, effectually reduced; and it has the advantage, shared by the arched or open breakwaters of the ancients, of affording a certain amount of water-way, and thus reducing its resistance.

We shall now direct attention to a fine specimen of marine engineering—Portland breakwater—than which this country does not possess a more useful work of the kind. It differs from Plymouth breakwater in not being an isolated structure, being connected at one extremity with the land.

So long ago as 1794 the natural conformation of Portland Bay, and the evident facility with which this natural harbour might be rendered safe and accessible in all winds by a judiciously-placed breakwater, attracted local attention, the idea

having first suggested itself to Mr. Harvey, the postmaster of Weymouth. In 1812 Alexander Lamb prepared a plan and estimate for a double breakwater—one behind the other—which should cost £400,000. Its length was to be one and a-half miles, or about the same as that now actually constructed, but its position was proposed to be further to the south. The subject was again renewed in 1836, when Rennie was consulted upon the matter. Still it remained in abeyance until 1844, when a Royal Commission, which was appointed to investigate the general question as to the advisability of establishing harbours of refuge upon the eastern and southern coasts of the kingdom, recommended Portland Roads as a suitable locality for a low-water harbour of refuge upon a large scale.

The position of these roads is singular. Bounded upon the south by the high land of Portland Island or Bill, it is most effectually protected from all winds from the south, and for several points to the east of south; whilst that very remarkable natural formation, the Chesil Bank, completely encloses it on the West. The Chesil Bank is an accumulation of shingle and boulders thrown up by the action of the tide and the heavy seas brought in with a south-west wind, and extends for many miles along the Dorset coast to the west of Weymouth; at the latter point it curves to the south, terminating in Portland Bill, which is by its means connected with the main land. It is frequently altered in shape and character by the action of storms, and varies in width; but as a natural buttress it withstands all the violence of wind and sea, and renders the capacious basin upon its eastern side almost landlocked, the only exposed point being from nearly due east, an exposure which it was the object of the proposed breakwater to obviate.

The plan proposed was to construct a breakwater extending in a north-east direction for 1¼ miles, commencing at a point near the north-east corner of the island. At the distance of a quarter of a mile from the shore, where the water averaged 42 feet in depth, there was to be an opening 50 yards across, to facilitate the ingress and egress of shipping. The area so protected would equal 1,200 acres, and the cost of the work was estimated at £500,000. This plan, with other modifications which need not be specified here, was eventually carried out.

The work may be said to have commenced by the depositing of the first stone by H.R.H. Prince Albert on the 25th of July, 1849; the quarries had, however, been previously opened out, and the necessary workshops, offices, and machines erected and prepared. The breakwater, as it now stands, extends due east from its starting-point for 1,800 feet in a continuous line of masonry. At this point there is a break or opening of a width of 400 feet. The stonework then continues in the same direction for 302 feet further, and then curves to the north for 1,200 feet, running towards Red Cliff Point for about 4,000 feet, where it terminates in a head standing in about 60 feet of water at low spring-tides. The total length is rather more than 1½ miles, and the space which intervenes between the Breakwater Head and the pier at Weymouth, which is the nearest land on the north side, is about 1¾ miles.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

IV.—INTERNATIONAL MUSEUMS: CLASSIFICATION OF EXHIBITS.

SECTION I.

CLASS I.—NATIVE PRODUCTS.

1. *Mineral products.* Metallic, non-metallic, gems uncut or *in situ*, mineral oils, wax, etc.; granites, sandstones, limestones, marble, alabaster, etc.
2. *Vegetable products.* Woods, roots, fruits, grain, hops, bark, hemp, flax, cotton bearers, oil, resin, perfume, colour producers, etc.
3. *Animal products.* Skin, hair, horn, fur, wool, feathers, silk, wax, oil, fat, flesh, perfume, colour producers, etc.

(Representing the economic natural history of countries.)

CLASS II.—IMPLEMENTS EMPLOYED FOR OBTAINING CRUDE PRODUCTS.

1. *In mining, quarrying, etc.*
2. *In agricultural operations, etc.*
3. *In fishing, shooting, hunting, trapping, etc.*

CLASS III.—APPARATUS AND PROCESSES EMPLOYED FOR THE EXTRACTION AND PREPARATION OF SUBSTANCES, ETC., USED IN MANUFACTURES.

1. *From mineral sources.* Metallurgy, chemical salts, colouring matters, mineral oils, paraffine wax, ozokerit, etc.
2. *From vegetable sources.* Potash, soda, and other chemical salts; colouring matters, perfumes, oils, tallow, flax, hemp, cotton, silk, etc.; gums, balsams, resins, etc.
3. *From animal sources.* Chemical products, perfumes, colouring matters, fats, oil, wax, silk, feathers, wool, fur, hair, leather dressing, ivory, bone, horn.

CLASS IV.—SUBSTANCES USED FOR FOOD.

1. *Mineral produce.* Mineral and aërated waters, etc.
2. *Vegetable and agricultural produce.* Flour, starch, sugar, tea, coffee, chocolate, beer, wines, spirits, tobacco, spices, pickles; preserved vegetables, fruits, sauces, essences, etc.
3. *Animal produce.* Salted, preserved, and potted meats, fish, lobsters, oysters, etc., essences.

SECTION II.

CLASS V.—MINERAL MANUFACTURES FOR BUILDINGS AND DECORATIONS.

Stone cutting, masonry, tombstones, etc.; mantelpieces, alabaster decorations; vases, etc., in various mineral substances.

CLASS VI.—GLASS MANUFACTURES.

Window glass, plain and stained, glass for household use and fancy purposes.

CLASS VII.—CERAMIC MANUFACTURES.

Porcelain, china, earthenware, bricks, cement, etc., for building, domestic, chemical, manufacturing, agricultural purposes.

CLASS VIII.—HARDWARE MANUFACTURES.

In tin, lead, zinc, pewter, brass, copper, iron, and steel.

CLASS IX.—STEEL, CUTLERY AND EDGE TOOLS.

CLASS X.—JEWELLERY.

Works in precious metals and stones, and their imitations.

CLASS XI.—MANUFACTURES IN FLAX AND HEMP.

CLASS XII.—MANUFACTURES IN COTTON.

CLASS XIII.—MANUFACTURES IN SILK AND VELVET.

CLASS XIV.—MANUFACTURES IN WOOL, WORSTED, AND MIXED FABRICS.

CLASS XV.—MANUFACTURES IN CARPETS AND FLOORCLOTH.

CLASS XVI.—PRINTED AND DYED FABRICS.

Woven, spun, felted or laid.

CLASS XVII.—LACE, EMBROIDERY, TAPESTRY.

CLASS XVIII.—MANUFACTURES IN HAIR AND LEATHER.

1. Hair cloth, hair felt, hair plumes, hair seating; human hair, wig, etc., makers; workers in hair devices.
2. Leather ornaments, buttons, cases, purses, fancy goods, hose buckets.
3. Leather stainers, dyers, embossers, gilders, enamellers, japanners, polishers.

CLASS XIX.—ARTICLES OF CLOTHING.

Hats, caps, bonnets, head-dresses, plumes, dresses, cloths, shawls, plaids, gloves, hosiery, boots, shoes, etc.; in all materials including hair, feathers, fur, skins, etc.; for men, women, and children.

CLASS XX.—FURNITURE AND UPHOLSTERY.

Furniture, upholstery, paper hangings, papier maché, and general decorations, dressing-cases and toilet articles, trunks and travelling apparatus, coffins, etc.

CLASS XXI.—PAPER, STATIONERY, PRINTING, AND BOOKBINDING.

1. Paper, card, mill-boards, envelopes, fancy stationery, ink, pens, pencils, sealing-wax, and wafers.
2. Samples of type-founding, wood type-cutting, electrotyping, stereotyping, etc.
3. Letter-press, copper, steel, zinc plate, lithographic, photographic, carbon, graphotype, anastatic, music, and numerical printing.
4. Bookbinding.

CLASS XXII.—EDUCATIONAL APPLIANCES.

1. *Buildings, fittings, furniture, appliances.* Plans, models of buildings and rooms, galleries, desks, and ink wells,

seats, lockers, teacher's tables, store-closets, black-boards, and supports, easels, cases, etc., for maps, diagrams, educational magic lanterns, school clocks, etc., for infant, primary, secondary, Sunday, adult, middle class, commercial, classical, industrial, trade, technical, medical, and art schools; lecture-rooms, museums, libraries, institutes, colleges, universities; swimming, riding, fencing, and gymnastic schools.

2. *Sanitary appliances.* For schools, colleges, and institutes; for heating, lighting, and ventilating, urinals, closets, lavatories, dormitories; for hats, cloaks, etc.; play, exercise, and drill grounds.

3. *Works and statistics on the theory and practice of teaching in all departments of education.* Roll-books, registers of attendance, progress, payments, tabular forms for collections, school statistics. Intended for the use of masters only.

4. *Apparatus for teaching in infant and children's schools.* Appliances for kinder-garten, for educating eye or hand. Dolls, doll's clothing, etc., models of articles of domestic use, furniture, ordinary workman's tools, and other object lessons; models of animals; diagrams of useful plants, and of those to be avoided as poisonous; ethnological groups, boxes of letters, numbers, abacus frames, dissected maps and globes, picture-books, instructive toys and games.

5. *Reading, writing, arithmetic, mensuration.* Books, tabular lessons, copies, diagrams, measuring instruments, etc., in graduated series, to suit classes.

6. *Geography.* Books, charts, maps, globes, models, diagrams, magic lantern slides, national surveys, etc., in graduated series, to illustrate physical, political, ancient and modern geography, natural phenomena, views of important places, their inhabitants, produce, manufactures, exports and imports, etc.

7. *History.* Books, chronological charts, diagrams, magic lantern slides, models, etc., to illustrate ancient and modern history, historical events, buildings, decorations, manners and customs, modes of warfare, etc., in chronological order, and in relation to the political geographical divisions of the globe, in graduated series.

8. *Religious instruction.* Books, catechisms, charts, maps, models, pictures, magic lantern slides, to illustrate Biblical geography, history, natural history, manners and customs of Eastern life; life, teaching, miracles, etc., of Jesus Christ; creeds of different sects, etc.

9. *Language.* Dictionaries, grammars, and works on the composition and analysis of sentences, philosophy and structure of language; courses of reading and instruction, etc., in ancient and modern languages; tabular lessons in parsing, etymology, and logical analysis, in graduated series.

10. *Mathematics.* Treatises and exercises on pure and applied mathematics, geometrical diagrams; models and drawings for elementary lessons on form and quantity, etc.; simple and cheap mathematical instruments; mariner's compasses, sextants, theodolites, levelling instruments, etc., for school use.

11. *Science.* Books, classifications, diagrams, magic lantern slides, apparatus, instruments, models, specimens, collections of typical forms and species, etc., to illustrate school courses on astronomy, meteorology, mechanics, physics, chemistry, mineralogy, crystallography, botany, zoology, osteology, anatomy, physiology, microscopy, geology; distribution of plants and animals in time and space; collecting appliances for field classes, cabinets, show-cases, etc., in graduated series, for schools, colleges, institutes, etc.

12. *Music.* Books, composition, exercises, diagrams, tabular lessons, cheap musical instruments and appliances for teaching the theory and practice of vocal and instrumental music.

13. *Art.* Books, materials, copies, diagrams; magic lantern slides of the works of the great masters, ancient and modern; models, casts, and appliances for teaching the theory and practice of drawing, colouring, painting, modelling, carving, sculpture.

14. *Domestic and social economy, etc.* Books, diagrams, magic lantern slides, models, etc., for illustrating instruction—

To males and females: On the laws of health, and the rudiments of domestic medicine, surgery, and nursing.

To females: On the selection of clothing, food, cooking utensils, and operations; furniture, management of household, servants, children, etc.

To males: On labour, wages, capital, the conditions of industrial success; moneys, weights, measures of the principal countries of the world, bookkeeping, paper money, bills, interest, discount, banking, investments, annuities, assurance, insurance; commercial and financial terms, rudiments of commercial and domestic law on agreements, leases, rents, bankruptcy, settlements, wills, methods of proceeding in inferior and superior courts, juries; instruction in the rudiments of industrial work, carpentry, turning, gardening, farming, management of pigs, poultry, horses, etc.

15. *Physical education.* Gymnastic apparatus, for indoor use and playgrounds; books and appliances for drill, general, military, naval, for boys, girls, and adults; and military and naval exercises, as single-stick, fencing, rifle-practice, riding, swimming.

Implements for chess, backgammon, archery, skating, cricket, foot-ball, croquet, skittles, bowls.

Rocking-horses, hoops, tops, marbles, and other toys.

16. *Appliances for educating the deaf, dumb, and blind.*

17. *Results of teaching.* Specimens of writing, plain and coloured drawings from maps, copies, models, nature, memory, modelling in clay, wax, etc.; needlework, plain and artistic; industrial work generally.

18. *Professional and special education.* Books, specimens, diagrams, magic lantern slides, instruments, apparatus, etc., employed in instructing mining, agricultural, chemical, pharmaceutical, medical, engineering, technical, military, naval, legal, clerical, and art students, at professional schools and colleges.

19. *Libraries.* Catalogues and specimens of collections of books, etc., classified for the libraries of schools, colleges, local institutions, and societies; lending and travelling libraries, etc.

Class XXIII.—Philosophical Instruments.

Mathematical drawing instruments, rules, scales, verniers, goniometers, dividing and gauging instruments, calculating machines, weighing instruments, balances, hydrometers, etc.; pyrometers, pressure and vacuum gauges, air pumps; barometers, thermometers, and other meteorological instruments; surveying instruments, rainmeters, sextants, acoustic apparatus, optical glass, prisms, lenses, mirrors, spectacles, ophthalmoscopes, heliostats, artificial sources of light, photometers, lighthouse apparatus, magic lanterns, dissolving view apparatus and slides, optical demonstrating appliances, spectroscopes, chromatic, diffraction, polarising apparatus, etc.; photographic apparatus, etc., stereoscopes, race and opera glasses, terrestrial, nautical, and astronomical telescopes, microscopes, thermotic, thermo-electric, electric, voltaic, electro-magnetic, magneto-electric, magnetic apparatus, chemical apparatus, etc.

Class XXIV.—Medical Appliances.

1. *Surgical instruments and appliances.*
2. *Pharmaceutical preparations.*

Class XXV.—Apparatus for Saving Life and Property.

Ambulances, etc.; sanitary appliances; life-boats, rafts, fire-extinguishers, fire-escapes, fire-engines, salvage appliances, life and fire office statistics, etc.

Class XXVI.—Horological Instruments.

Watches, clocks, astronomical clocks, etc., and trades connected therewith.

Class XXVII.—Musical Instruments.

Accordions, concertinas, bag-pipes, seraphines, harmoniums, organs, tambourines, drums, harmonicons, trumpets, horns, bugles, flageolets, flutes, oboes, guitars, harps, violins, violoncellos, pianofortes, cymbals, musical bells, triangles, military musical instruments, musical boxes, and other self-acting musical instruments.

CLASS XXVIII.—CIVIL ENGINEERING, ARCHITECTURE, AND BUILDING APPLIANCES.

CLASS XXIX.—MILITARY ENGINEERING, ARMS, AND ACCOUTREMENTS.

1. *Tents, camp equipages.*
2. *Clothing and accoutrements*, with representations of the costumes, etc., of all arms of the army service.
3. *Armour, arms, ordnance, etc.*

CLASS XXX.—NAVAL ARCHITECTURE AND APPLIANCES.

1. *Ships of war, tackle, rigging.*
2. *Arms, ordnance, etc.*
3. *Clothing and accoutrements*, with representations of the costumes, etc., of all arms of the naval service.
4. *Ships of commerce, barges, boats, rigging, tackle, etc.*
5. *Steam-ships, boilers, engines, etc.*

CLASS XXXI.—LOCOMOTIVE APPLIANCES.

1. *By air.* Balloons, etc.
2. *By road.* Coaches, carriages of all kinds, harness, saddlery, and stable appliances, velocipedes.
3. *Railway and tramway appliances.* Railway plant, locomotive engines, carriages, method of signalling, etc.

CLASS XXXII.—MACHINERY AND TOOLS.

1. *Employed in the manufacture of mineral and metallic wares and goods.*
2. *Employed in spinning, weaving, etc., the manufacture of wood, etc.*
3. *Employed in the manufacture of ivory, horn, etc.*
   [Unless distributed in connection with the special manufactures for which they are employed.]
4. *Machinery in general.*
5. *Machinery in motion.*

SECTION III.—FINE ARTS.

CLASS XXXIII.—PAINTINGS in oil, water colours, distemper wax, enamel, on glass, porcelain.

CLASS XXXIV.—SCULPTURE.—Modelling, carving, and chasing in marble, stone, wood, terra cotta, metal, ivory, glass, shell, precious stones, and other materials.

CLASS XXXV. — ENGRAVING, ETCHING, LITHOGRAPHY, PHOTOGRAPHY, ETC.

CLASS XXXVI. — ARCHITECTURAL DESIGNS, DRAWINGS, MODELS, ETC.

CLASS XXXVII.—ART DESIGNS FOR MANUFACTURES.

1. For all kinds of decorative manufactures.
2. Tapestries, carpets, embroideries, shawls, lace, fans, etc., shown for the fine art of their design in form or colour, and not as manufactures.

CLASS XXXVIII.—REPRODUCTION OF WORKS OF ART.

Copies of ancient or mediæval pictures, mosaics, enamels, of ancient works of art, etc., in plaster, fictile, ivory, electrotype, etc.

The above classification is founded on that drawn up by H.M. Commissioners for the International Exhibition of 1862, but is modified so as to bring certain groups of an allied character into closer connection than was therein arranged, with the object of facilitating their study by visitors having a common interest in two or more branches of inter-related manufactures, while other groups of modern origin are more fully elaborated as to their details, where their scope is not fully comprehended by the public at large. Thus the literary, educational, philosophical, surgical, pharmaceutical, sanitary, and life and property preserving appliances are here arranged in succeeding classes, instead of being widely separated, as in the grouping of trades and manufactures in 1862. The necessarily numerous subdivisions of the educational department, contributed to by so many trades and manufactures, are here fully elaborated as a suggestion for the future, when it is to be hoped the respective groups of this class may be contributed to by all nations, and the collection displayed in one gallery. An international exchange of ideas on the methods and appliances for teaching in all departments of knowledge, under good organisation, would prove of great value, when our school boards are discussing schemes as to what to teach and how to teach. Under the thirty-eight classes specified in the above classification about 300 trades should find a place, the greater number of which are enumerated in alphabetical order in H.M. Commissioners' List, published in the *Society of Arts Journal*, Vol. IX., No. 458, August 30, 1861.

NOTABLE INVENTIONS AND INVENTORS.

XXV.—CHARLES BABBAGE, F.R.S.

BY JOHN TIMBS.

THIS celebrated mathematician and mechanician, one of the most active and original of original thinkers, and whose nar ? has been known through the length and breadth of the kingdom for nearly half a century, was born on the 26th of December, 1792. His father, Mr. Benjamin Babbage, of Totnes, in Devonshire, came to London, and became a partner in the banking-house of Messrs. Praed, Mackworth, and Babbage. Little is known of Charles Babbage's early life; but it is stated that he was so weak in body and mind, that it was not considered worth while to send him to school, and he was left to ramble about the fields and commons; and it has been suggested that the ramblings of the child may have prepared the foundation for those habits of thought which formed the mathematician, while his early weakness may account for his irritability. On getting stronger, he was educated at the Totnes Grammar School, and then sent to the private school of the Rev. Stephen Freeman, of Forty Hill, near Enfield, from whom young Babbage imbibed an intense love of mathematics, and where he had for schoolfellows the late Captain Marryat, the novelist, and Mr. William Carr, of Brighton, who still (1871) survives.

At the usual age Mr. Babbage was entered at the University of Cambridge, and his name appears in the list of those who took their bachelor's degree from Peterhouse in the year 1814. It does not, however, figure in the Mathematical Tripos, he preferring to be Captain of the Poll to any honour but the Senior Wranglership, of which he knew Herschel to be sure. While, however, at Cambridge, he was distinguished by his efforts, in conjunction with Sir John Herschel and Dean Peacock, to introduce into that University, and thereby among the scientific men of the country in general, a knowledge of the refined analytic methods of mathematical reasoning which had so long prevailed on the Continent, whereas we in our insular position, for the most part, were content with what has been styled "the cramped domain of the ancient synthesis." Keeping this object steadily in view, in the first place the youthful triumvirate translated and edited the smaller treatise on the "Calculus" by Lacroix, with notes of their own, and an appendix (mainly, if not wholly, from the pen of Sir John Herschel) upon "Finite Differences." They next published a selection of the exercises on all parts of the "Infinitesimal Calculus," a volume which is still of great service to the mathematical student, in spite of more recent works with a similar aim. To this publication Mr. Babbage contributed an independent essay on a subject at that time quite new, the solution of "Functional Equations."

In 1828, Mr. Babbage was placed in Newton's chair as Lucasian Professor of Mathematics in his University, and he held that chair eleven years, but, it is believed, never lectured. He soon afterwards produced his "Tables of Logarithms," upon the preparation of which he bestowed the highest care. In order to diminish the fatigue of constantly picking out figures from black and white pages, he experimented upon tinted papers, and their effects upon the eye, the result being that his logarithms were partially printed upon green and fawn-coloured sheets. These logarithms were used in the calculations of the whole of the Trigonometrical Survey of Ireland, and in those of the English Survey from the period of their publication; they were also printed for foreign circulation.

In the year 1832 Mr. Babbage published his very popular work, "The Economy of Machinery and Manufactures," which presents a series of summarisations rarely approached. It originated in ten years' visits made to workshops and factories, in England and on the Continent, for the purpose of endeavouring to make himself acquainted with the various resources of mechanical art, when he was insensibly led to apply to them principles of generalisation which regulate the application of machinery to arts and manufactures, as most important either for understanding the action of machines, or enabling the memory to classify and arrange the facts connected with their employment. Or a still more lucid explanation of the object of the volume is—"to point out the effects and advantages which arise from the use of tools and machinery, to endeavour to classify their modes of action, and to trace both the causes and the consequences of applying machinery to supersede the skill

and power of the human arm." Sometimes this talent of Mr. Babbage exhibited itself in unexpected directions. Thus, a writer in the *Athenæum* states:—"We have heard an eminent artist refer to an exposition of the principles of imitation in portrait painting, which Mr. Babbage addressed to him in the shape of a letter, and which our informant regards as the best essay on that branch of art which has ever come under his notice." This is, indeed, a charming work, and well do we remember reviewing it, nearly forty years since, and being strongly impressed with the talent and taste which made it "as entertaining as a fairy tale." It was translated into French, German, Italian, Spanish, and Russian. Four years later, Mr. Babbage wrote "The Ninth Bridgewater Treatise," a work designed by him at once to refute the opinion supposed to be implied and encouraged in the first volume of the "Bridgewater Series," that an ardent devotion to mathematical studies is unfavourable to a real religious faith, and also to give specimens of the defensive aid which the evidence of Christianity may receive from the science of numbers, if studied in a proper spirit. This is one of the best known of Mr. Babbage's works for its important social bearings.

The "Decline of Science," which Mr. Babbage published previous to the above work, was received in a different spirit; its statements were freely controverted, especially in a clever pamphlet published in 1831, and entitled "On the Alleged Decline of Science in England," by a foreigner, with a prefatory note by Faraday. The pamphlet contains but thirty-two pages, yet it disposes of the writer's argument in a compass rarely recognisable in controversies. The reader will find the question of the comparative national encouragement of science in England and in France, in a long quotation from Mr. Babbage's work, in the "Arcana of Science and Art," 1831, pp. 62—66. The same opinion was still further worked out by Mr. Babbage in a book on the Great Exhibition of 1851, which he published twenty years ago. He wrote also an autobiographical memoir, entitled "Passages in the Life of a Philosopher." Altogether, with a wonderful grasp of mind, he wrote nearly eighty papers for different learned societies and scientific periodicals.

We now approach Mr. Babbage's crowning scientific effort, the invention and partial construction of the famous calculating machine or engine, with which his name has long been associated, and will go down to posterity. Machines for performing arithmetical calculations were common before computations by the pen. The Roman *abacus* was the oldest instrument of this kind; it was employed in the south of Europe till the end of the fifteenth century, and in England to a later period. It consisted of counters, movable in parallel grooves, or on parallel wires, in a frame, and having the different denominations, as the units, tens, hundreds, etc., according to the grooves in which they were placed. In China, where the system is decimal, this instrument, called Schwampan, is used with great rapidity; and from the Chinese merchants, at the great fair of Novogorod, the Muscovites first learnt the use of the abacus, since it is at the present day the common mode of reckoning in the shops of Moscow. This is the simplest form of calculating machine.

Pascal, when scarcely nineteen years of age, constructed a machine for executing the ordinary operations of arithmetic; and of this he executed more than fifty models in ivory, ebony, and copper, before he completed it. But he experienced the usual neglect of cultivators of science: "the French monarch had, indeed, given him the exclusive privilege of his invention, the right of expending his time, his money, and his health, in perfecting a machine for the benefit of France and the world; but like a British patent bearing the great seal of England, it was not worth the wax which the royal insignia so needlessly adorned." (*North British Review*, No. 2.)

Pascal's machine had a resemblance, though faint, to that invented by Mr. Babbage. It was an assemblage of wheels and cylinders; on the convex surfaces of the latter were the numbers for performing the operations, as the addition and subtraction of sums of money, having the denominations of livres, sous, and deniers, for which may be substituted pounds, shillings, and pence; and to these denominations the numbers were adapted; attached to the axles of the cylinders were toothed wheels, which were turned by pointers; the additions being performed by means of the numbers in the lower series of the numbers on the cylinders, and the subtractions by means of the numbers in the upper series on the cylinders. Pascal's machine excited a considerable sensation throughout Europe, and six eminent men of science devoted all their mathematical and mechanical skill to improve Pascal's machine, but without success. In the excellent article on "Calculating Machines" in the "Penny Cyclopædia Supplement," it is remarked, "Where many sums of money are to be added together, some time may be saved by the use of such a machine; but the processes for subtraction, multiplication, and division would be more tedious, and perhaps more liable to error than those which are performed by the pen." Subsequently to the time of Pascal, Leibnitz invented a machine which is believed to have surpassed Pascal's both in ingenuity and power; but he left no detailed account of its complicated mechanism, and perhaps all that is known of it is, that by wheel-work the operations of multiplication and division could be performed without the successive additions or subtractions which would be required if Pascal's machine were used.

The possibility of constructing a piece of mechanism capable of performing certain operations on numbers we have shown to be by no means new; but never before or since has any scheme so gigantic as that of Mr. Babbage been anywhere imagined. While all previous contrivances performed only particular arithmetical operations under a sort of co-partnership between the man and the machine, in which the latter played a very humble part, the invention of Mr. Babbage actually substitutes mechanism in the place of man; and if carried on to the extent proposed, would constitute one of the most superb monuments of human ingenuity. It calculates astronomical, logarithmic, and navigation tables, as well as tables of the powers and products of numbers. It can integrate, too, innumerable equations of finite differences; and, in addition, "it does its work cheaply and quickly, it corrects whatever errors are accidentally committed, and it prints all its calculations!" (*North British Review*, No. 2.) It was intended not only to perform arithmetical operations with absolute certainty, but also to transfer the results immediately to copper plates, from which any number of copies may be printed without a possibility of error.

This grand invention of the age was first mentioned in a letter from Mr. Babbage to Sir Humphry Davy, dated July 3, 1822, in which he describes a small model of his engine for calculating differences (hence Mr. Babbage prefers to call it a "difference engine"), which produced figures at the rate of forty-four a minute, and performed with rapidity and precision all those calculations for which it is designed;" and Sir H. Davy witnessed and expressed his admiration of the engine. The letter was sent to the Treasury, and submitted to the Royal Society, when upon the recommendation of a committee, Mr. Babbage, at the desire of the Government, undertook, in 1823, to superintend the construction of such an engine. He bestowed his whole time upon the subject for many years, during which about £17,000 had been expended by the Government in the construction of the difference engine. A considerable part of this sum had been advanced by Mr. Babbage for the payment of the workmen, and was, of course, repaid; but it was never contemplated by either party that any portion of this sum should be appropriated to Mr. Babbage himself, nor did he receive a single shilling of the money, in any shape, for his invention, his time, or his services; a fact which Sir Robert Peel admitted to the House of Commons in March, 1843.

"Early in the year 1833, a small portion of the machine," Mr. Babbage tells us, in the "Ninth Bridgewater Treatise," "was put together, and it performed its work with all the precision which had been anticipated." In the previous year, Sir David Brewster, in his "Natural Magic," had borne testimony to the working of the engine in these words:—"Great as the power of mechanism is known to be, yet we venture to say that many of the most intelligent of our readers will scarcely admit it to be possible that astronomical and navigation tables can be accurately computed by machinery; that the machine may itself correct the errors which it may commit; and that the results of its calculations, when absolutely free from error, can be printed off, without the aid of human hands, or the operation of human intelligence. All this, however, Mr. Babbage's machine can do, and as I have had the advantage of seeing it actually calculate, and of studying its construction with Mr. Babbage himself, I am able to make the above statement on personal observation. . . . The greater part of the calculating

machinery is already constructed, and exhibits workmanship of such extraordinary skill and beauty that nothing approaching to it has been witnessed. In order to execute it, particularly those parts of the apparatus which are dissimilar to any used in ordinary mechanical constructions, tools, and machinery of great expense and complexity have been invented and constructed, with contrivances of singular ingenuity. The drawings of this machinery, which form a large part of the work, and on which all the contrivances had been bestowed, and all the alterations made, cover *upwards of* 400 *square feet of surface*."

Sir David Brewster, concluding with some observations upon "that class of individuals who envy all great men, and envy all great inventions," averred that Mr. Babbage's invention was not new, reminding them that "its function, in contradistinction to that of all other contrivances for calculating, is to embody in machinery the method of differences, which has never before been done; and the effects which it is capable of producing, and the works which in the course of a few years we expect to see it execute, will place it at an infinite distance from all other efforts of mechanical genius." We may here note that a popular account of Mr. Babbage's engine will be found in his interesting volume "On the Economy of Machinery and Manufactures," to which we have already referred.

Early in 1833, the construction of the difference engine was suspended, on account of some dissatisfaction with the workmen. Some twelve months after this, about October, 1834, writes Mr. Babbage, "I commenced the design of another and far more powerful engine. Many of the contrivances necessary for its performance have been discussed and drawn according to various principles, and all have been invented in more than one form. I consider them even in their present state [April, 1837] as susceptible of practical execution, but time, thought, and expense will probably improve them. The new engine will calculate the numerical value of any algebraic function; that, at any period previously fixed upon, or contingent on certain events, it will cease to tabulate that algebraic function, and commence the calculation of a different one, and that these changes may be repeated to any extent. The former engine would employ 120 figures in its calculations; the present is intended to compute with about 4,000."

The analytical engine, as this new machine was called, could not exist without inventing for it a method of mechanical addition possessed of the utmost simplicity. In fact, it was not until twenty different modes for performing the operation of addition had been designed and drawn, that the necessary degree of simplicity required for the analytical engine was ultimately attained. These new views acquired additional importance from their bearings on the difference engine, already partly executed for the Government, for if such simplifications should be discovered, it might happen that the analytical engine would execute with greater rapidity the calculations for which the difference engine was intended; or that the difference engine would itself be superseded by a far simpler mode of construction; and these views were subsequently completely realised. To have resumed the construction of the difference engine while these new views were withheld from the Government, would have been improper; yet the state of uncertainty in which these new views were involved, rendered any written communication respecting their probable bearing on that engine a matter of very great difficulty.

From the year 1833 to the close of 1842, Mr. Babbage repeatedly applied to the Government for its decision upon the subject. These applications were unavailing. Years of delay and anxiety followed each other, impairing those energies which were now directed to the invention of the analytical engine. Amid such distractions, the inventor steadily pursued his single purpose. The drawings and the notations were freely shown, and the great analytical engine was explained and discussed by some of the first philosophers of the day. Copies of the engravings were sent to the libraries of several public institutions. Throughout the whole of these labours, neither science, the institutions, nor the Government of the country, ever afforded the inventor the slightest encouragement! When the invention was noticed in the House of Commons, one single voice alone was raised in its favour. One night, when Mr. Wakley inquired of the Minister when it was likely the calculating machine would be completed, he was jocularly recommended to set the engine to *calculate!* During upwards of twenty years, Mr. Babbage maintained in his own house in Dorset Street, and at his own expense, an establishment for aiding him in carrying out his views, and in making experiments, which most materially assisted in improving the difference engine. When that work was suspended, he still continued his own inquiries, and having discovered principles of far wider extent, he ultimately embodied them in the analytical engine. The establishment necessary for the actual construction of the difference engine, and of the extensive drawings which it demanded, as well as for the formation of tools to overcome the novel difficulties of the case, and the drawings and notations of the analytical engine, gave occupation to a considerable number of workmen of the greatest skill during many years. To render the drawings of the difference engine intelligible, Mr. Babbage had invented a compact and comprehensive language (the mechanical notation) by which every contemporaneous or successive movement of the machine became known.

PRACTICAL APPLICATION OF THE FINE ARTS.—VII.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

We now give two more illustrations of the way in which figures may be treated. In the one we have the head, in the other the figure. As will be perceived at once, the head in this case is more fully elaborated than in our last, and an amount of accessory and consequently of leading is introduced. We have here, too, a male head, that of an ecclesiastic; consequently a deeper tone of glass may be employed than would be befitting a female, especially a female of a rather delicate style of beauty; but the tone will not be so deep as if it were intended to represent an older or less refined style of face. Much depends upon the choice of appropriate glass, whether of tone, tint, or texture. Tone, to a great extent, depends upon the position in the general design; if the subject be a large one, upon the amount of shade or prominence to be given to the individual figure; for, as in the old tale, it is not only necessary to paint each individual grape aright, but the whole bunch must be arranged and toned. Tint must have reference to contrast with surrounding subjects, to the age and character of the person to be portrayed, and the various colours to be brought out by shade and stain. Texture, too, should have some connection with the style of beauty, but this must also be reckoned according to the position the window is to occupy, whether only slightly above the level of the spectator or at some considerable height.

We have, in our second paper, alluded to this consideration of position and adaptation to the intended site, but we cannot impress too strongly on the mind of the designer that the probable and commonest position of the spectator must be carefully provided for. We know that in theatrical scenes the perspective is so arranged as to afford a perfect illusion when seen from the centre of the house, but that if viewed from either side everything is more or less out of proportion and out of joint. With a window placed at a great height it must be the same. If a person on the floor, say, of a church, has to crane his neck up to an angle of 60° or more, the lines which to his eye would form a handsome and impressive countenance, would appear repulsive and ridiculous from the clerestory on the opposite side of nave or transept. These things must be considered, and when a satisfactory design has been accomplished it must be put *out of drawing* in order to give the purposed impression from a different stand-point. This may be done by calculation, by increasing all the perpendicular lines in a certain ratio, whilst keeping the horizontal measurements the same; or it may be accomplished by fixing a point at a certain height above the flat table on which the drawing is to be made, suspending the original design opposite to this, and copying as fairly as possible the effect required upon the surface inclined at the required angle to the eye. It should be remembered in the former method, however, that the upper parts of the design have to be exaggerated rather more than the lower.

This alteration of drawing will be found very advantageous in one respect, and that is, that long, narrow windows, or lights, so common in Gothic buildings, can, when placed at a height, be made available for designs which otherwise would be quite unsuitable for them.

Our glass being chosen, and the design brought into the required shape, let us now proceed to the actual painting. The outline, as before, can be traced, and in this part of the work the bold, vigorous work of the draughtsman, who feels sure of every line, is easily distinguished from that of the mere copyist from the design of another. It is in this vigorous treatment of the drawing that oftentimes the amateur glass painter, if he be really an artist, and certain of his powers of delineating what he intends, so far excels the mere mechanical manufacturing workman, who is far more skilled in the technicalities of his art. The workman, therefore, who would compete for honour and fame in the practice of this art, must really study fine art; he must cultivate his taste, and educate his hand and eye by every means within his reach; and he will not find that the time spent in the art-school at conscientious work, with pencil or crayon, will be thrown away, even from a pecuniary point of view.

The outline being fixed in, an amount of stippled shading must be laid on down the side of the face and neck, but this must be kept light, so that afterwards another coating of shade may be added, which shall partake something more of the character of the lines by which this shading is represented in our wood-cut. The great object is to keep up the transparency of the glass, and this is done partially in the stippling, by the interstices of light which penetrate where the brush touches the glass, but it is still better accomplished by cross-hatching of lines. In fact, the shading of glass very closely resembles the corresponding work in a good chalk drawing. First, the stippling answers to the rubbing in of shade with the stump, and, like it, can be modified to a certain extent by rubbing out lights when the oxide is dry; then the decided chalk lines are represented by hatching lines, made with the long flexible brush; and finally, even the high lights may be slightly imitated by grinding away in some cases the surface of the glass, or by the use of acid.

The shading being fairly accomplished, the stain may be put in, and in this again there is room and necessity for much judgment. It will not do that all the hair should be of the same hue, and however enticing the colour may be, it will not always be suitable that the female figures should be all alike endowed with the fashionable hue of the day. Judgment, experience, and a knowledge of the results of various combinations alone will give what is requisite to cause an agreeable variety.

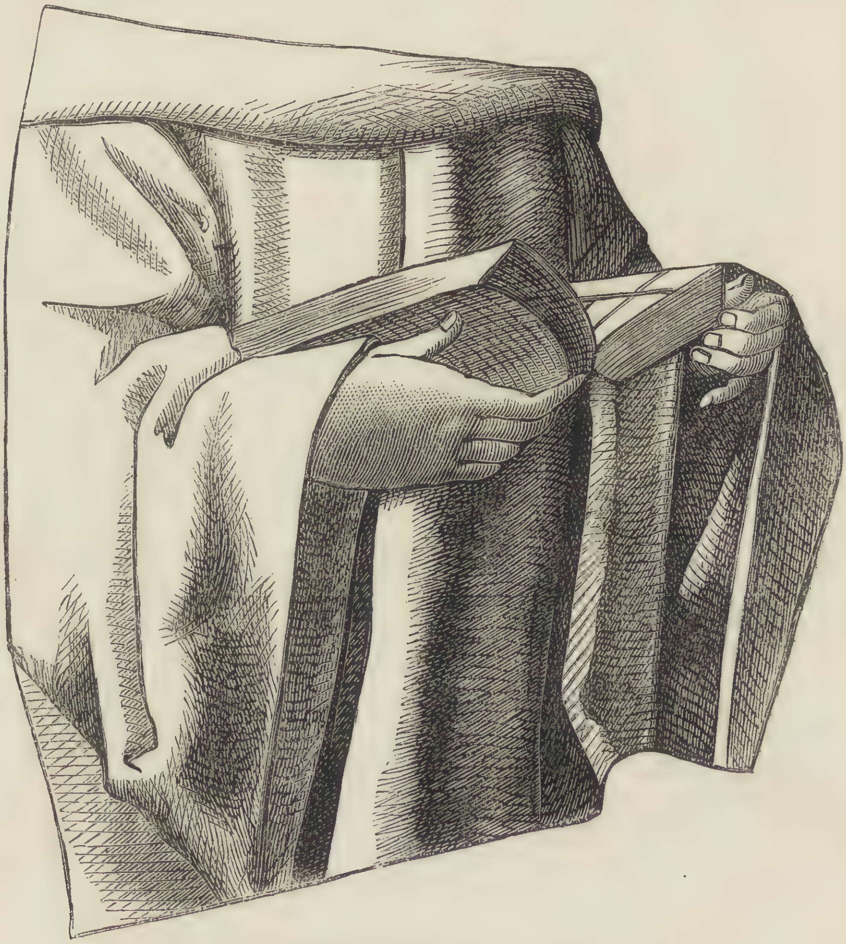


Fig. 12.—FIGURE WITHOUT A HEAD HOLDING A BOOK.

The gems upon the bishop's mitre (Fig. 13) have been represented sometimes by the addition of knobs of coloured glass attached to the surface of the glass. This practice, however, is not common, nor is it always desirable. There is considerable doubt whether the additions will always adhere sufficiently to last as long as the window endures, and even if there were no other objection, the process partakes too much of the nature of a trick of art to be altogether pleasing.

Our other illustration (Fig. 12), taken from the singing men in Cologne Cathedral, shows the one point in which the Germans excel, ease of posture and careful and good drawing. The hands are natural and unexaggerated, the book lies open for use, and the drapery falls in massive and intelligible folds. There is no straining after effect, and the success leaves one in a comfortable frame of mind, neither anxious to discover the answer to unsolved enigmas, nor elated at the discovery of ideas implied but not developed.

Fig. 13.

SOLDIERING.—II.

BY A STAFF OFFICER.

OBJECT OF WAR—MORAL FORCE—SYSTEMS OF RECRUITING ARMIES.

In studying, then, the process by which an army is organised, it will be necessary to keep very clearly in view the double purpose of perfecting the material structure, and of infusing into it the spirit which is both to render it powerful, and to place it perfectly in the hands of him who rules it. The one purpose is in fact to develop material, the other that which for want of a better name we are obliged to call "moral force."

Greatly as modern wars are always affected by constantly progressive material improvements, and important as it is therefore to inquire with reference to any army to what extent preparation has been made in its organisation for taking full advantage of these, nevertheless it will be necessary for us to consider even more carefully to what extent the moral force has been developed. For, in the first place, the development of that force is the more difficult part of the problem, and, in the second, the difference between the most perfect and the most imperfect development is less easily discovered till it is too late.

We may cite the universal experience of history to prove that ultimately success depends on the extent to which the power of the *armies* for fighting has been broken on one side or the other. The numerical difference between the lists of killed and wounded of the victors and vanquished is usually very slight. Very frequently the victors have up to the moment of complete victory suffered most. In what then has the great loss of power sustained by the vanquished consisted? In the capacity for cohesion for united, continuous, and effective action. Now this capacity constitutes no small part of that which we mean by moral force. All this is equally true in the detail of fighting; for the best evidence appears to show that the accounts of large bodies of men whose material opposition has continued up to the last moment when it was possible to offer it are very nearly all fables. Long before men actually run they have under the circumstances of fight become so "demoralised" as to cease to fire with effect. Now to quote from a pamphlet which, as it was used in the instruction of the officers of the victors in the late gigantic struggle up to the moment when they were entering upon it, and after they had recently won a campaign, their success in which Europe was inclined to attribute chiefly to the mechanical improvements which they had adopted, may be cited as proof that what we are urging is not based on any sentimental affection for the mere term "moral force," but on practical deduction from the actual study of war. "What, for instance, is the good of the best rifle in the hands of the most practised shot if the eye is blinded and the hand trembling with excitement? It is on the moral force of the troops, then, that the fate of battles mainly depends; and no tactical study can be of any real value which does not take it into account, or which subordinates it to mere questions of form or system."*

Nevertheless, the forms and the systems may very largely indeed affect the extent to which we can succeed in developing the "moral force" which we require in our army, and this we shall immediately have occasion to note as we proceed to examine the distinctions between different methods of organisation. In the first place, then, since in order to create our army at all, we must have some means of obtaining a regular supply of men, and since "moral force can hardly be created, the germs of it at least must exist in the individual soldier," it becomes in the last degree important to consider the effect which different systems of enlistment are likely to have in supplying an army with these "germs" of moral force. It is clear that we are much more likely to be unaware of the influence which is thus being produced than we are to be unconscious of the effect upon the mere numbers which we obtain.

The means by which armies have been recruited have differed somewhat in each period of history, and in each country in that period, but it will be convenient at present to limit the statement to the systems of the present day or of recent wars. We may include all systems under the heads of the "voluntary" method and the "compulsory." The latter, the "compulsory," is, however, of two very distinct kinds, which may be conveniently classed as "conscription" and "universal service:" the former, that which has till lately been the system pursued in France; the latter, that which has been almost forced on all Continental powers by the brilliant success which has attended its adoption by Prussia. The principles on which the voluntary and the compulsory systems are severally based are, the one, that it is best for the general good that the service of the State should be supplied at the ordinary market rate; the other, that every citizen has a duty which he is bound to perform, and from which he is only to be excused on general grounds of high State policy. The broad distinction between the "universal service" system and that of conscription is that while the principle on which both are based is carried out in the one in its integrity, in the other it is in practice so modified that its essential features disappear.

Under the system of "universal service" as understood in Prussia, every one who arrives at the age at which he is fit to enter the military service has to present himself to be medically examined for the army. It does not in the least follow that his social position will be violently changed. If he has certain social advantages of position he can retain these, provided he shows that the service which he is able to render the State is proportionally valuable. But he must ultimately prove by rigid tests that his social position has been so used as to enable him to offer more valuable service in war, either as an officer or volunteer soldier, than he could by entering the ranks at once as a private. Except for sons who are the sole support of widows or of parents unable to support themselves, there is no exemption on the ground of personal inconvenience. From the number who present themselves, those are selected who from their *physique* are best qualified for the work required of them. Those who after they have been allowed full time for development are not selected for the army, are kept as a reserve, and sufficiently trained to fill up vacancies should their services be wanted. Thus though the number actually to be taken into the service is fixed for each year, according to what is considered necessary to supply the required force, the State distinctly exercises its claim to the service of all, and makes its own selection of those who are best suited to fulfil the work which it requires. None are permitted to fly of their own choice from the service as from a plague. It is only in the last resort, when the number of those who reach the highest standard of efficiency is too great for convenient use, that a ballot is resorted to which determines whether the man shall join the *ersatz* reserve or the active army. Not, therefore, to be passed for the service is in some sort a mark of at least physical inferiority.

On the other hand, under the late French system, the number of the army having been fixed, the selection of those who were to be taken was by ballot. An immense number of special exemptions were permitted, most of them based on considerations as to the personal convenience of the exempted. Hence, to be exempted became a privilege, and if that privilege could be obtained by personal deformity, it was then also a distinction on which to be congratulated, not a disgrace which courtesy would induce others to pass by unnoticed; the ballot became simply a means of determining who should not escape like the more lucky ones. It seemed natural that if any were such vagabonds as to be willing for a consideration to undertake an unpleasant lot, they should be permitted to do so instead of those who were rich enough to escape from it; societies were formed which insured their subscribers against being taken for the army as against any other piece of misfortune. This arrangement being at a later date abolished, in consequence of the proved inferiority in all respects of the substitutes provided, money was paid to the government instead of the companies by the man who wished to be exempt; the only difference being, that the imperial officials, not being under the same restraint as the societies, pocketed the money, and did not provide any substitutes.

If we take all these facts into consideration, it becomes clear enough that the difference in the material prepared for the two armies did not consist by any means only in the disproportion

* "About Tactics," by Captain Laymann, Instructor in Tactics at the Royal War School, Cassel. Translated by Captain E. M. Jones, 20th Foot, F.R.G.S.

of numbers, but that the respective systems tended to produce within the army itself very different feelings as to the duties which each man owed to the service to which he belonged.

Comparing now these two with the so-called voluntary system, it is extremely important to note the difference which exists between names and facts. For since one great point is to get men who are willing to learn their business, surely a "voluntary" must be better than a "compulsory" system. But does a man enlist with a much more hearty love of his profession who is driven into it by hunger than by a law which he finds pressing with equal justice upon all his acquaintances high and low? Or supposing again that by a misconception of the nature of the work you intend afterwards to call upon him to do, a man is induced to enter the army, who fancied he was going at once to enter upon a very splendid career, and finds that he has to obey orders and scrub tables, will the service you obtain from him be very willing?

Now both these dangers surround the circumstances of a voluntary service. There is constant danger, on the one hand, lest the material with which you have to deal should become very inferior in consequence of the number of men who enter your service because their characters render them unfit for other work. On the other hand, in a country where those who do not intend themselves to have any connection with the army, have no reason to trouble themselves further about it, as all must do where "universal service" prevails, there is very apt to be an almost absolute ignorance prevailing as to what goes on within it. Hence a desire arises, which is sure with most of the classes who cherish it to lead to bitter disappointment, that they should be able to enter the ranks of an army so ordered that it will provide them with an all but certain and splendid career. That the spirit with which this class would infect the mass is distinctly mischievous towards the objects which are most essential in army organisation, we shall have abundant occasion to note as we proceed. "La carrière ouverte aux talents" is the typical cry. It essentially represents that disintegrating selfishness which split up the French army; can accurately be translated into English only as "universal struggle for place;" and is directly opposed to that principle with which it is often confounded, that the one great object to be secured is that the nation shall be provided with the best obtainable servants, each for their special work, and that no personal or class disadvantages shall interfere with the selection. The points, therefore, which with a voluntary service appear most essential, in order that its best features may be fully developed, are that the most perfect possible means shall be provided for enlightening those who have to select their profession as to the nature of the service they will adopt if they enter the army; that the conditions shall be as attractive as they can be made irrespective of pay, without injuring the service itself, in order that the best possible class of recruits may be obtained; but that the principle shall be rigidly enforced, that the good of the service must in all things be made the primary consideration, and that those who enter must be taught that they must volunteer to contribute their quantum to the efficiency of the whole, and that all personal considerations are to be made subsidiary to that. If these conditions are understood beforehand, the principle of voluntary service has then this immense advantage over the compulsory, that the same elective process is brought into play which exists with other professions, namely, that each man selects the one for which he believes himself to be the most fitted, and that he is subject to no slight private criticism in the matter by those who know him best. Very great efforts have been made of late years in England to introduce these latter advantages into our system. The old false plan of public-house enlistment by puffing sergeants and high bounties has been given up. Plain placards are now printed to show what the actual terms are on which a soldier enlists, stating in the fairest possible manner what prospects of pay, etc., he has before him. Various means, such as the creation of reading-rooms, etc., have been devised to give him the means both of amusement and self-instruction.

As to the obtaining of the number of men we require, that is after all in the main a question of how many we *do* require, and is one which must be answered differently for every country. Wisely or unwisely, it has at present been left in England a question of purely private speculation, and no authoritative declaration has been issued on the subject, though it is reported that a committee appointed to investigate the question has recommended that we should be always ready to put into the field anywhere a body of about 60,000 men fully equipped, and that we should have available for home service an effectively equipped body of 350,000 men, 200,000 of whom should be able to take the field. It is hardly necessary to say that at present we have no force of the kind, though in what respect our deficiencies are most pressing will become clearer as we proceed. In any case, at present no evidence has been forthcoming to show that in mere numbers it will be impossible to satisfy our requirements without resorting to compulsory service, though there is very considerable danger lest, from not having made up our minds clearly as to the force we wish to have available, we should be obliged suddenly to increase the quantity at the expense of the quality of our recruits—a process with which we are all familiar under the smooth sounding title of "lowering the standard of enlistment;" that is to say, admitting unformed, weakly men, because we cannot get well-formed, strong ones, the mere difference in the height allowed not at all representing the really important difference between the men. It is as an attempt to meet this difficulty that the system of draughting men off into the reserves has been instituted, in order that whilst maintaining strictly the same standard we may, when we obtain an excess of men, pass them into our reserve, and so continue to enlarge, without considerable expense, the number of men of proper *physique* on whom we can rely in case of any sudden necessity. It must be remembered, moreover, that our requirements are altogether different in kind from those of Continental nations, for while we are not exposed to the same danger of invasion as they are, so long as our navy is mistress of the sea, we have far distant possessions to defend, the garrisoning of which is by far the severest task which our army has to undertake. Since you can scarcely require a man compulsorily to expatriate himself for half a life, it appears certain that even the most eager advocates of compulsory service would not propose to extend its provisions to the whole army in the same manner in which that is done in Prussia; it is clear, therefore, that entirely new conditions come into play. In any case, the relative advantages of the two systems, in so far as the mere provision of the proper numbers is concerned, is a question almost entirely, as it has been well said, of the nature of the foreign, Indian, and colonial policy of the country; the numbers required, and therefore the possibility of obtaining them under a voluntary system, varying almost indefinitely in accordance with the different principles which we adopt on those subjects.

Passing to an inquiry into the relative cost of the two systems, it is obvious at once that if you insist on a man's giving you his service for any rate of pay you like to fix there will be a much smaller bill for total expenses than if you are obliged to pay all whom you employ at the ordinary market rate. It by no means follows that the real cost to the whole country will be less; for you have, in fact, been exacting from those whom you employ a very heavy tax indeed in addition to that which appears in your estimates. Each man who has had to serve for less than he otherwise would be earning has contributed just that difference between the pay he has received and the pay he would otherwise have received to the coffers of the State. In relative estimates between the cost of the Prussian army and our own this is almost invariably forgotten. Mr. Cardwell quoted (17th of February, 1871) from a report which very ably pointed out how this acted in the case of France, where substitutes being allowed, those who wished to escape had each to pay about £100, which of course helped to supply the cost of the army, and was an immense additional tax on the country most unequally levied. But it is obvious that where no substitutes are allowed the tax actually levied is much heavier, for this £100 only represents what large numbers of men were glad to pay in order to escape the yet heavier fine to them of being obliged to sacrifice their other opportunities of earning a living. Moreover, looking at the question in a larger economical point of view, the pecuniary loss which the country sustains from losing the services of many men from situations in which they largely contribute to increase the general wealth, and employing them in positions which others of less education and faculty could equally well have fulfilled, is an element which must be taken very seriously into the account.

TECHNICAL DRAWING.—LVII.

GOTHIC STONEWORK.

DECORATED ENGLISH CAPITALS.

THESE, as a rule, follow the contour of the pier in clustered columns, and are either bell-shaped or octagonal. They are frequently only moulded, presenting rounds, ogees, and hollows, in which the ball-flower (Fig. 496) or square flower (Fig. 497), the prevailing ornaments of the period, are set. The abacus is either circular or polygonal in plan, and its mouldings are composed of rounds frequently with an overlap of ogees and hollows. The foliage is gracefully wreathed around the bell, instead of rising direct from the neck moulding. The difference will be at once understood on comparing Fig. 498, from York Cathedral, with the group of capitals in Fig. 479. The leaves of oak, maple, vine, ivy, strawberry, hazel, ferns, etc., are all so beautifully rendered as to give evidence of their having been studied directly from nature. The oak seems to have been an especial favourite. Figs. 499 and 500, crockets from Hereford and Lincoln Cathedrals, and Figs. 501 and 502, finials from Cherrington Church and York Cathedral, are beautiful examples of the application of natural foliage, and illustrate the development of these ornamental features at this period.

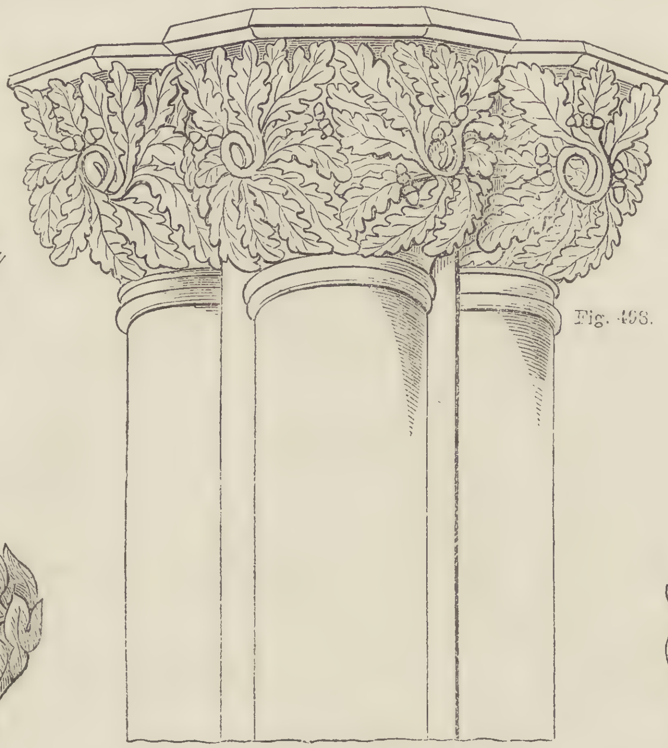


Fig. 498.

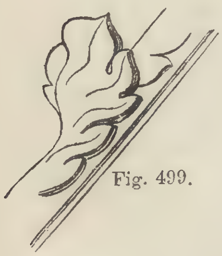


Fig. 499.

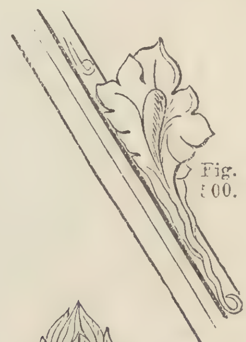


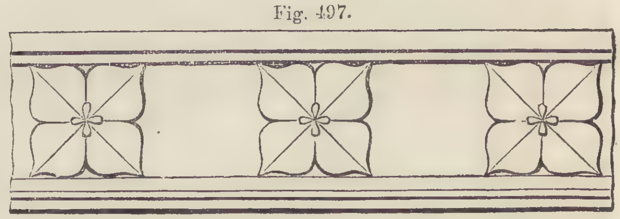
Fig. 500.

Fig. 501.

Fig. 502.

Fig. 496.

Fig. 497.



The doorways of this style possess very much the same features as in the last, but the mouldings, jamb-shafts, etc., are more slender, less undercut, and generally of finer proportions; the hollows being often filled with the ball-flower and square flower, applied in the same manner as the dog-tooth was in the Early English. The jamb-shafts differ from those used in the last period in being constantly engaged. Many doorways, however, are without pillars, being entirely composed of mouldings which are continuous with those in the architrave. The door-arches are frequently surmounted by a triangular or ogee canopy, ornamented with crockets and a finial, the spandrel being filled with sculpture of various kinds.

The large doors of this period are sometimes double, though not as generally so as in the last style; but the single doorways of the Decorated period are often nearly as large as the double ones of the Early English. On the sides of the doorways small buttresses or niches are sometimes placed, and in some a series of niches, with statues, are carried up like a hollow moulding; whilst in others, doubly foliated tracery hanging freely from one of the outer mouldings, gives a richness superior to any other decoration.

DECORATED ENGLISH WINDOWS.

These are usually large, and contain from two to seven lights; but there are also windows of single lights, of less elongated form than in the Early English period.

The variation from the character of the last period is here distinctly marked, first, in the employment of mullions instead of shafts with capitals and bases, but more especially in the full development of tracery.

It will be remembered that tracery originated in the necessity for piercing the portion of the wall which was left vacant when two lights were gathered under a single-arched dripstone, and thus the whole of the elementary tracery was necessarily in one plane, consisting merely of apertures in a flat surface. As the principle of window-tracery, however, became established, the mullions were recessed from the face of the wall in which the window-arch was pierced, and the fine effect thus produced was, as the art progressed, speedily enhanced by the introduction of distinct orders of mullions, and by recessing certain portions of the tracery from the face of the primary mullions and their

corresponding tracery bars.* The distinct planes of tracery and mullions thus produced constitute one of the most beautiful features in Gothic windows.

Decorated window tracery is divided into geometrical and flowing. In the former the tracery consists of combinations of lines producing numerous geometrical figures—curvilineal, triangles, lozenges, etc. etc., and others based on them, and merge into each other, thus producing a blending of forms, and resulting in what has been called "flame-like compartments."

In its most perfect state, geometrical tracery invariably exhibits some large figure of a distinct and decided character, which occupies the entire upper part of the window-head. This figure is generally a circle, itself foliated and cusped, or

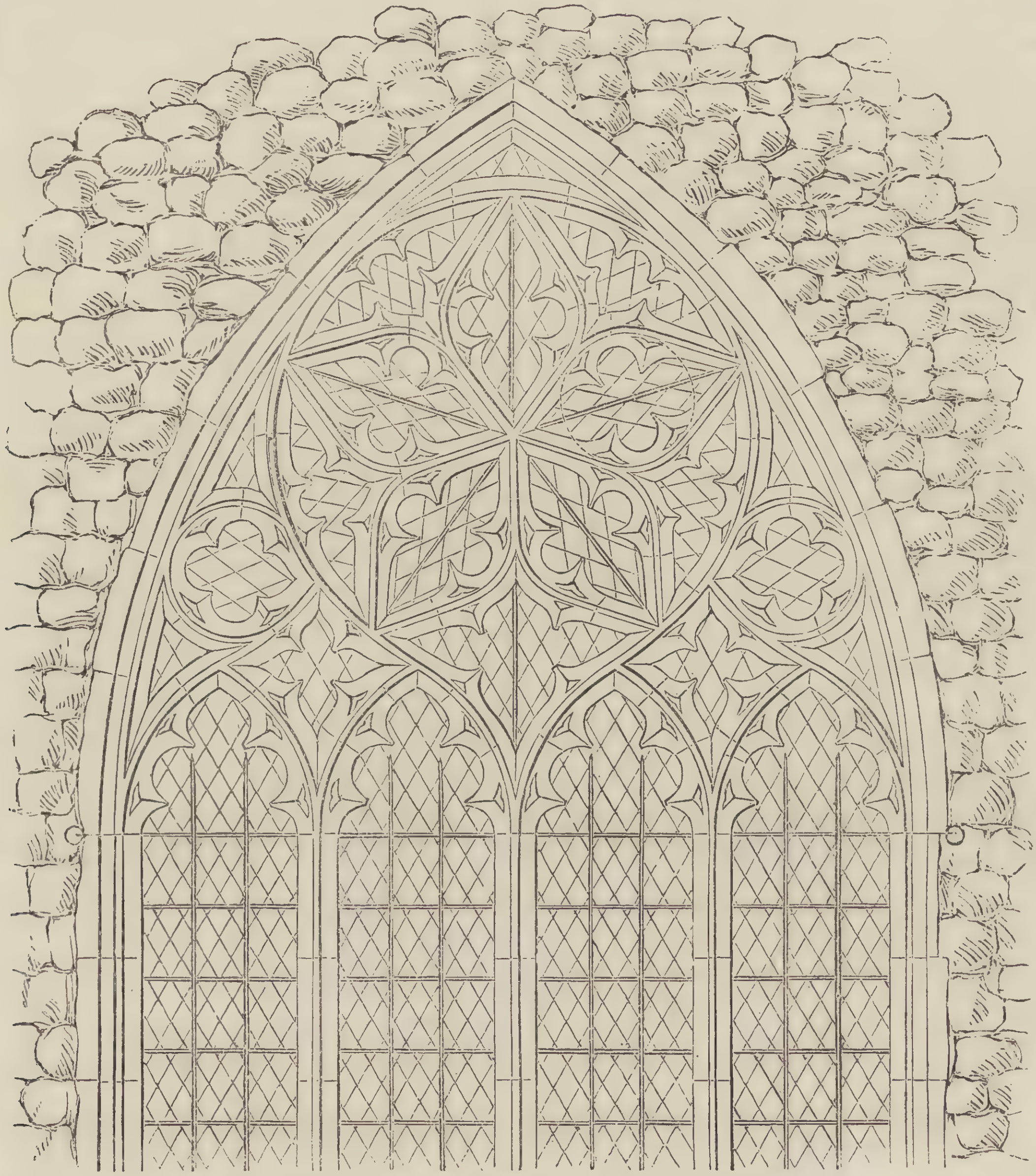


Fig. 503.—WINDOW FROM BOUGHTON ALUPH CHURCH, KENT.

combined with circles, as the trefoil, based on the triangle; the quatrefoil, on the square; the cinquefoil, on the pentagon; the hexafoil, on the hexagon, etc. In the flowing tracery these figures, though still employed as a basis, are not each completed in themselves, so as to stand out individually; but they subdivided by smaller geometrical figures, in most cases similarly enriched; or it is formed by tracery bars diverging from the head of the central light in such a manner as to resemble the upper portion of the window arch inverted, and containing ornamental work of the same character as that in the large circles.

The window in Fig. 503 is from Boughton Aluph Church, Kent, and is a good, though not a rich, specimen of geometrical tracery. The figure on which the central portion of the head is based has already been given in lessons in "Practical Geometry applied to Linear Drawing."

* *Tracery bars* are those portions of the masonry of a window-head which mark out the principal figures of the design. From these the minor and more strictly decorative parts of the stonework may be distinguishable under the name of "form pieces."—*Willis's "Nomenclature."*

PHOTOGRAPHY.—IV.

By J. C. Leake.

OPERATIONS IN DARK ROOM FOR SENSITISING PLATES—EXPOSURE OF PLATES FOR RECEPTION OF PHOTOGRAPH—DEVELOPMENT OF IMAGE—FIXING OF IMAGE.

The plate will now be ready for immersion in the sensitising bath of nitrate of silver; and from this time forward, until the picture is fixed, the whole of the operations must be conducted in the yellow non-actinic light of the dark-room, with the exception, of course, of the exposure to light in the camera. The yellow shutter of the room being closed, the plate may be sensitised by placing it with the lower coated edge upon the ledge of the dipper, and lowering it steadily and quickly down into the bath solution. Like the operation of coating, this also requires some skill and practice in order to effect it properly. The plate must be lowered quickly and regularly into the solution, as if the slightest jerk be imparted, or any hesitation be made, the result will be that a straight line, corresponding with the surface of the solution, will be left upon the plate, which, in the finished picture, will appear as if the glass was cracked at that point. After remaining at rest in the bath for some two or three minutes, the plate should be lifted by means of the dipper, and raised and lowered alternately ten or twenty times, in order to facilitate the escape of the ether and alcohol retained in the film. It will, at this stage, be observed that the surface of the film presents a somewhat greasy appearance, from the fact that the nitrate-of-silver solution does not mix freely with the alcohol and ether in the collodion. As soon as this resistance has been partially overcome, the position of the plate should be reversed upon the dipper, and the movement resumed until the solution flows in a smooth and even sheet over the whole surface. When this occurs the plate is sensitive to the action of light, and is ready for exposure in the camera. The process above described will have produced a very marked difference in the appearance of the plate. The transparency will now have given place to a creaminess and semi-opacity, owing to the combination of iodides and bromides contained in the collodion with the silver in the bath solution, the result being a film of bromo-iodide of silver of most exquisite sensitiveness to the action of the light.

While the plate has been in the nitrate bath, the dark slide of the camera should have been dusted, and wiped out with a damp cloth, and a few folds of clean blotting-paper laid upon the operating-table at the foot of the bath. These preparations made, the plate may be lifted out of the solution, and, after draining a few moments into the bath, be placed upon one end upon the blotting-paper, in order that all the superfluous moisture may drain off its surface. The back of the plate should then be carefully wiped with a tuft of soft paper, and the plate placed in the dark slide with its sensitive surface inwards. It is a good plan to insert a sheet of red blotting-paper at the back of the plate in the slide, in order that it may absorb any of the silver solution which may drain out of the film during exposure. It will be scarcely necessary to add, that the utmost care must be exercised in all these operations, in order that the sensitive surface be not injured, as it would be by the slightest touch either of the finger, or any substance whatever. After the sensitised plate has been placed in the slide, no time should be lost in exposing it to the action of light in the camera. It is true that it will retain its sensitiveness for perhaps half an hour after the removal from the bath, but it is at least running a considerable risk of failure, from stains caused by the partial drying of the films, if more than half that time be allowed to elapse between the sensitising and developing processes. Plenty of time may be occupied in exposure for all practical purposes, but none should be wasted or lost.

Before removing the slide containing the plate from the dark room, it should be lightly wrapped in a cloth of some opaque material, in order to shield it from any stray ray of light which might find its way to the sensitive surface and cause "fogging." The slide should be brought to and from the camera in the same position in which it was placed when the plate was inserted; and on no account must it be reversed, or knocked about, if the utmost perfection be required in the resulting picture. On arrival at the camera the focussing-screen should be removed, and the cap placed upon the tube holding the lens; the slide with the sensitive plate should then be inserted in the groove from which the screen has been taken, and the cloth thrown over the whole of the camera, of course, with the exception of the lens. The hand should then be inserted under the cloth, and the sliding-shutter gently and steadily lifted to its full extent. All will now be ready for the actual exposure of the plate to light, and after allowing a few seconds to elapse, in order that any vibration caused by the adjustment of the slide may subside, the cap may be gently removed and the plate exposed. The time during which this exposure is to be continued cannot be definitely given, as it varies with the aperture of the lens, the colour and lighting of the object to be photographed, the nature and character of the light, and many other matters. We may, however, suggest that, for an ordinary brick or stone building, partly in sunlight and partly in shade, with a lens of six inches focal length and an aperture of a quarter of an inch, the time of exposure necessary will be from twenty to fifty seconds. The only test of this matter will be the development of the image, of which we shall treat presently. When the exposure is completed, the cap should be replaced, the slide closed, and the plate removed to the dark-room for development, with precisely the same precautions as were before observed in bringing it for exposure.

Upon arrival in the dark-room, the plate must be removed from the slide and held in the left hand, precisely as during the process of coating with collodion. In the right hand the glass containing the iron developing solution should be taken, and the fluid should be spread from the lower right-hand corner completely over the plate with one quick and even sweep. There is no occasion to be sparing with the developing solution, and the important point here is to completely cover the whole surface with one application of the solution. If any hesitation be made in effecting this, from an insufficient quantity of solution, or from improper or imperfect spreading of it, lines and stains will be caused similar to those produced by hesitation in lowering the plate into the sensitising bath, and the picture will be spoiled. If the exposure in the camera has been properly timed, in a very few seconds after the developing solution has been applied the sensitive surface which, upon removal from the camera-slide bore no trace of an image, will begin to change in appearance; the highest lights, those parts upon which the light has acted most strongly, showing signs of becoming darker. The developing fluid must be kept in motion over the plate by rocking it backwards and forwards, so that the solution may flow equally over the whole surface. Gradually the whole details of the picture will appear; the highest light—such, for instance, as the sky—assuming a semi-opaque character, while in the deepest shadows the film of iodide of silver will remain nearly unaltered in appearance. If necessary, a second application of the developer may be made; but if a proper exposure to light has been given this is seldom required. When the whole of the details of the picture have been developed, the iron developing solution must be washed off, taking care not to disturb the film, which, it should be remembered, is exceedingly delicate, and liable to be removed from the glass by any violent treatment. The proper place in the dark-room in which the process of development may be conducted is immediately in front of the window, in order that the progress of the work may be examined by light transmitted through the plate. If the image be now examined, it will be observed that it is entirely reversed, the sky being dark and the shadows light; the proportion of light and shade, being, however, accurately preserved. If there should be sufficient density in the deposit thus formed, the operation of making the negative would be complete; but where the image is produced upon bromo-iodised collodion and developed with iron this is seldom the case, the negative being generally very soft and full of detail, but without density sufficient to resist the light during the process of printing. A second treatment is therefore necessary, in order to render the negative fit for printing, and add a sufficient thickness or opacity for the purpose. In order to effect this the solution of pyrogallic acid is employed as follows:—After a thorough washing of the plate and the complete removal of the iron solution, the second developer—or more properly the intensifying solution—is poured over the plate several times until it flows quite evenly upon the surface. A few drops of the ten-grain solution of nitrate of silver should then be added, and the mixed solutions applied as before. A rapid

acquisition of density will be the result, and when the sky and the lights of the picture are so opaque as to only allow the outline of the finger applied to the back of the plate to be seen through them, the application of the fluid to the surface should be discontinued, and the solution washed off as quickly as possible. In ordinary cases, one application of the re-developer will be sufficient, but it may be continued as often as necessary, renewing the solution as soon as it becomes discoloured. Beginners often make their negatives too intense; and we should advise the tyro to obtain a good printing negative, by which he could guide himself in his work in this important particular.

The only chemical process now remaining to be effected is that of fixing the image, or dissolving out the unaltered portions of the sensitive film. This is a very easy and simple affair, in which there is but little risk of failure. If the hyposulphite of soda be used (which we should advise), the plate should be placed upon the ledge of the dipper, precisely as in the sensitising process, and immersed in the solution, where it should be left during some five or ten minutes. Upon removal from this bath, it will be found that the unaltered iodide of silver has been dissolved, and that the deepest shadows almost resemble the bare glass. If this be the case, and the high lights present a creamy appearance, and are semi-opaque, the operation may be considered successful, and the negative fit for printing. The hyposulphite solution must be very thoroughly washed off with a copious supply of water, and when the film is dry the negative will be fit for varnishing. If the cyanide of potassium is employed for fixing the image, it should be poured upon the plate and carefully watched, being washed off thoroughly as soon as the iodide is dissolved, or it will attack and dissolve the image itself.

When the film is thoroughly dry, the plate should be varnished before attempting to print from it, or it will inevitably be destroyed. The negative should be held in front of a clear fire until it is quite warm, but not hot. It should then be held by one corner and coated with varnish, exactly as it was covered with collodion, and with the same care. The varnish will dry into a bright, hard, and glossy surface, when the negative picture may be considered complete and ready for printing from.

For the sake of clearness we have avoided all mention of failures; but as these will most probably occur in one or other of the various stages, we will consider them and their causes and remedies in another chapter.

FISH CULTURE.—IV.

By Greville Fennell.

ARTIFICIAL FECUNDATION AND INCUBATION.

We still pursue the description of M. Gehin's plans, for their simplicity; and we have seen that in artificial fecundation Nature has been imitated, where the fish voids its eggs by passing over and pressing its belly against smooth stones. This natural method being imitated by the hand of the operator, all the eggs are evacuated, without the loss of a single one.

In artificial incubation M. Gehin takes a round box, in the form of a warming-pan, except that the bottom rises a little in the inside in order to make it remain more firm in the position in which it may be placed. It is made of zinc, to prevent rust; its size is twenty centimetres in diameter and seven centimetres in depth; the lid four centimetres in height, on hinges with a catch. The box is pierced on every side, so that the water can freely flow through it over the gravel. These holes are a millimetre in diameter, and should be very carefully and smoothly made with a punch, in such a manner as not to wound the little fish attempting to escape through them.

The bottom of the box is covered with a bed of fine gravel, and on this are placed the fecundated eggs. Each box should contain one brood of eggs. The box is then closed, a hole is dug for it in the gravelly bottom of a running stream of fresh water in which it is placed, and gravel is strewed over it.

It is necessary to take these precautions in order that the water flowing through the gravel may be purged of its impurities before it enters the box, and not deposit mud or slime upon the eggs, and retard and prevent altogether the hatching, as Gehin and Remy observed was the case when such precautionary measures were omitted.

The box so placed is left for a month or two. M. Gehin could not determine the exact time of the process of incubation, as it varied with the quality of the water. "This question," says M. Godevier, "is now occupying the attention of scientific men, and from their researches we shall have the exact results. As incubation goes on and hatching time approaches, in order to determine when it will take place, and not to their injury retain the little fish too long prisoners, the boxes should be frequently inspected. When incubation is finished, and the little fish begin to move, they must still be kept enclosed from eight to fifteen days, according as their numbers are small or great; then they may be set at liberty in the quietest part of the stream, care being taken that the quality of the water is the same as that which has flowed through the boxes, for a change to water of more or less freshness or clearness will have a sensible influence on their frail existence.

"A wide field was here, of course, open to any one who chose to enter upon it: for example, it was very interesting to ascertain the results of different modes of treatment by placing similarly, either confined in large boxes or at liberty in running brooks, equal numbers of young fish, and supplying one set with thickened blood, ground liver, and other food, and leaving the other set to find such food as Nature affords, to note the relative increase. Experiments, likewise, might be made with boxes having larger holes than those before described—large enough for the escape of the young fish as soon after hatching as they might seek their liberty, which mode might do away with the necessity of watching the process of hatching, with the view to opening the boxes soon after.

"In some sections of the country, where many crops have been gathered from the same plot of ground, it becomes in a degree exhausted, and, whether to improve it for the same or prepare it for another kind of crop, it is usual to overflow it, converting it into a fish pond, and stocking it with carp and tench. After three or four years the water is drawn off, the fish taken and sold, and the land cultivated. A few years having elapsed, it is again overflowed, but need not again be stocked with fish, as they now appear, as it were, spontaneously. We have the evidence of numerous observers as to this fact, and among others the inhabitants of a commune near Grenoble. They state that there is a little lake on the side of a hill in the commune of Jarrie, not far distant from their town, which is well stocked with carp and tench. Sometimes the lake dries up, and the ground is then cultivated with hemp, and yields abundantly; and again it is filled with water, and carp and tench appear in great quantities.

"The river Drac has a wide bed, and the current at times reaches new channels or re-takes old ones which have dried up; in the pools of these old channels soon appear quantities of trout, whose size shows their age to date from the period of the water's return. This fact is vouched for by the fishermen of that river. The inference is clear, that the fecundated eggs have been left in the bed of the channel at the time it dried up, and so remained until the returning waters have united all the necessary elements of incubation, which has then taken place, and soon after the eggs have been hatched."

Founded on these facts M. Gehin adopted the following mode of preserving and transporting fecundated eggs:—

He takes one of the boxes already described, and covers the bottom with a bed of very fine sand; he covers this with a layer of gravel or pebbles, varying in size from a pea to a hazel-nut, and upon the gravel he spreads a layer of fecundated eggs; these again are covered with sand, and then another layer of gravel, and then one of eggs, and so on, until the box is filled. He takes great care beforehand to wash the sand and gravel so as to free it entirely from every particle of mud or slime.

When the box is full he dips it in water, so that its contents shall be thereby more closely packed together; and being thereafter exposed to the air it can be sent anywhere without altering the condition of the eggs. On the receipt of the box the contents are taken out and placed in five or six other boxes, each containing the spawn of one female; and these are placed in the gravelly bed of a stream, according to the directions before given as to artificial incubation.

If any of the eggs have a different appearance from that before described, as fitting them for incubation, they must be

thrown away; and the cleaner the eggs are the better will be the success of the experiment. The sterile and spoiled eggs become white and opaque, like the white of a hen's egg boiled, and if broken yield a milky fluid.

M. Gehin meets a difficulty in a characteristic way. Trout fishing is prohibited in France during spawn time—that is, during November and December—because the fish, coming then together in shoals, can so easily be taken and the work of reproduction prevented. But fishermen, stimulated by large profits and lessened toil, brave the law, and destroy in the germ millions on millions of fish. To these fishermen he gives this advice: they should take with them a little pot made of zinc, say five inches in diameter and six inches deep; it should be filled one-third full of water, and a piece of wood the size of the pot may cover the water to prevent its splashing out as the pot is carried from one place to another by the fishermen while at their work. When they take a female fish they should put her eggs in this pot, and in like manner put into it the milt from the male fish. M. Gehin thinks it unimportant whether the milt or the eggs be first placed in the pot; that will depend on whether the female or male is first caught. When they have done fishing they should dig a hole in the bed of the current near where they have been fishing, and cover the bottom with fine gravel; into it they should pour the eggs, which, when fecundated, will drop to the bottom among the gravel like little shot; the hole should then be filled up with little stones and covered with gravel, and incubation will go on, and in due time the eggs will be hatched. "By this means," adds M. Gehin, "the fishermen, by reaping all the advantage of their illegal trade, will not be, in fact, doing any injury to the process of reproduction."

It has been observed that fish are with difficulty acclimatised on being taken from one stream to another; often they die, almost always they become sterile. But eggs so transported are easily incubated and hatched, and produce fine fish. Indeed, it has been remarked that, except in a running stream, other fish than carp and tench become barren. When fish are caught for the purpose of taking from them the eggs, and are found to be in an unfit state to be operated upon, from not having gone their full time, they should be kept in a reservoir until the proper time, and then relieved of their eggs and set at liberty again. Otherwise they will die in the reservoir, as they will not, while in that manner kept prisoners, spawn naturally, but will retain their eggs and perish. When eggs are preserved in water, it must be frequently renewed, or aquatic plants be placed in it: these plants preserve the eggs in an unchanged condition.

As an evidence that there is something wrong in the exercise of those experiments which are so continually announced as failures either partial or complete, we quote from a French work upon the subject of breeding fish, which says: "Like all other great discoveries, now that we have it, this seems the simplest in the world. How, we ask ourselves, was it possible for any one to eat fish-roe without thinking of the innumerable fish thus destroyed in the germ, and what would that thought lead to but the search for a mode of preventing such wholesale slaughter and the easy discovery of such a mode? Yet it took six thousand years to find the right means to solve readily and practically the difficulty; and we now *have the solution in so simple a form that even the children of fishermen practise it as easily as they would tend a flock of sheep.*"

Next was demonstrated the possibility of creating at will mixed breeds, by mixing the spawn and milt of two different species; and the author shows the possibility of hatching artificially, near ponds containing unproductive species, the eggs of these very species, and of stocking these ponds with young fish from these eggs. Every part, indeed, of his research is characterised by such exactitude and practical good sense, that all fundamental questions are resolved; and this new discovery had hardly appeared in the domain of science when it was transferred to that of industry.

In 1841 the late Mr. Boccius, C.E., to whose zeal and observation we can from a long acquaintance personally testify, carried to still greater lengths practical results of such experiments. He, like those who preceded him, made use of artificial fecundation for stocking the streams of Mr. Drummond, in the Colne near Uxbridge, and he estimated the number of trout he produced and brought up there at 120,000. We, however, who continuously fished this water, never found any appreciable increase of sport, nor did we notice any greater number of trout after a year or so, in the pools or in the shallows. But these fish, as they are migratory, may have worked either up or down the stream, and thus benefited neighbouring waters more congenial to their nature. We possess several MSS. of Mr. Boccius, which tend to show the earnestness of purpose by which he was actuated, and could have wished that the results had been more in accordance with his exertions, and from his very failures there is much to be learned. Our own opinion is that there have been some faulty observations here. He says one part of his system is to breed none but the superior classes and qualities of fish, the finest costing no more trouble to protect and feed than the inferior kinds.

Fig. 12.—SALMON LEAP—SHOWING HOW THE LEAP OF THE FISH IS EFFECTED.

Owners of waters should be cautious against grasping at too much, either in weight or numbers. Large fish devour far more in proportion than smaller ones; and too great a number of a lesser size eat up the food, and the whole stock becomes lank and lean. Again, the larger fish hunt and harass their weaker brethren, and hinder them from obtaining food. On this account, where many exist the fishery is not upon a fair footing, and certainly not in a progressive or prosperous state. It were better that large fish, after a certain age, should be taken for food, or else removed for productive purposes elsewhere. Fish which can obtain their food in an easy and peaceable way will increase far more rapidly than those which have to travel for it. This explains the seeming contradiction that trout in some waters are only in condition two or three months in the year. The simple answer is, that eight months of the twelve they are, from scarcity of food, so starved that they are compelled to feed upon the smaller sort of their own fraternity. These, being swift of movement, become difficult to take; so that the fish are more like skeletons, or heads and tails of trout, than fish worth taking, and do not get into condition till the fly season comes round again.

Those who have permission from owners to take eggs from trout or salmon, cannot be too careful in handling the fish; above all, they should never touch the gill or gill-covers so as to injure them, for if a fish bleeds from the gills he is sure to die. "He must not be squeezed, but you must hold him gently round the small of the tail (the 'wrist' I call it) with the left hand, and keep his head loosely in the hollow of the right hand. Sometimes the eggs are white, sometimes amber colour. Do not throw the fish rudely back that are not ready, but carry them to the water and slip them gently in—like one slips a ferret into a rat-hole. Female fish, if faint, should be supported, head up stream, in the hand, until they swim away of their own accord. If you are in doubt of the eggs being ripe, take one of them in your mouth, and bite at it; if you find it soft and can catch it easily between the teeth, and it cracks, you may be quite certain that the egg is not ripe; if, however, on the contrary, you have a difficulty of catching the egg between the teeth, and it slips away from between them, feeling like a ball of glass, and you have a difficulty to crack it, the egg is perfectly ripe. When the eye of the young fish is visible in the egg, the external transparent horn-like shell of the egg is quite hard, tough, and very elastic; for if you drop an egg in this condition, it will rebound like an india-rubber ball. This is a wonderful provision of Nature to preserve the young fish from the superincumbent weight of the gravel."

PRINCIPLES OF DESIGN.—XXVII.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

SILVERSMITHS' WORK (*continued*).

HAVING chosen a form for a vessel, the next question with which we have to deal is, will it require a handle and spout? It is curious that while the position of a spout and handle in relation to a vessel is governed by a simple natural law, we yet rarely find them placed as they should be. This is the more curious, as a vessel may become practically of immense weight, owing to the handle being misplaced.

A pound weight is easily lifted, but when applied to the shorter end of the steelyard it will balance a hundredweight. If this principle is applied to a tea-pot which actually weighs but little, it may yet be very heavy to lift. In nineteen cases out of twenty, handles are so placed on tea-pots and similar vessels that they are in use lifted only by a force capable of raising two or three such vessels, if the principle of the steelyard was not acting against the person who uses the vessel. Take our ordinary form of tea-pot, and see how far the centre of the weight (the centre of gravity) is from the handle in a horizontal direction, and you will be able to judge of the leverage acting disadvantageously to the person who may pour tea from such a pot. Now if the part held is to the right or left of a right line passing through the centre of gravity of any vessel, there is leverage acting to the disadvantage of the person desiring to pour from that vessel, and this increases just as the point held is removed from the central line spoken of.

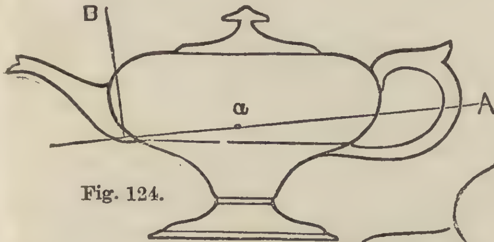


Fig. 124.

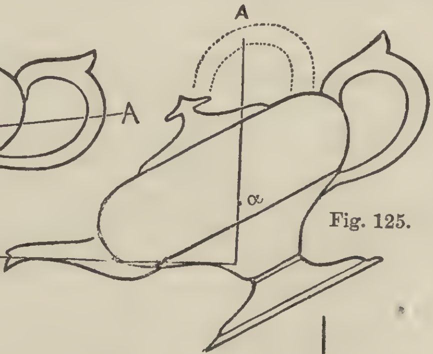


Fig. 125.

Fig. 129.

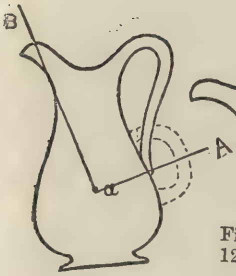


Fig. 133.

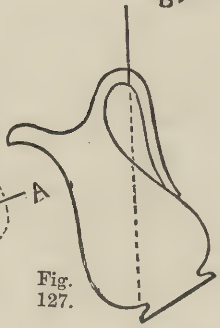


Fig. 127.

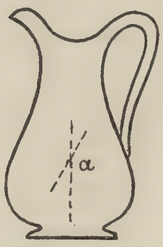


Fig. 128.

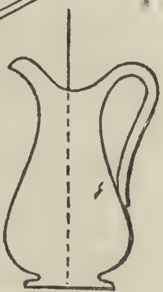


Fig. 126.

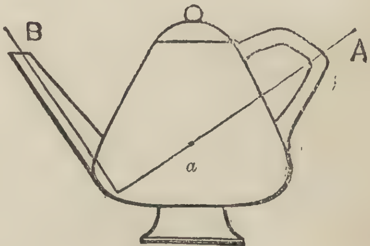


Fig. 130.

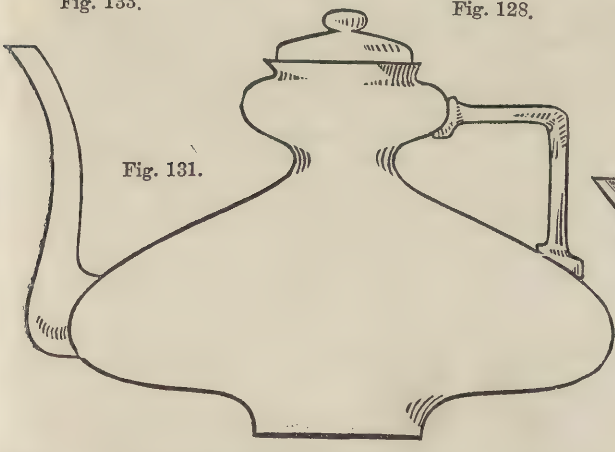


Fig. 131.

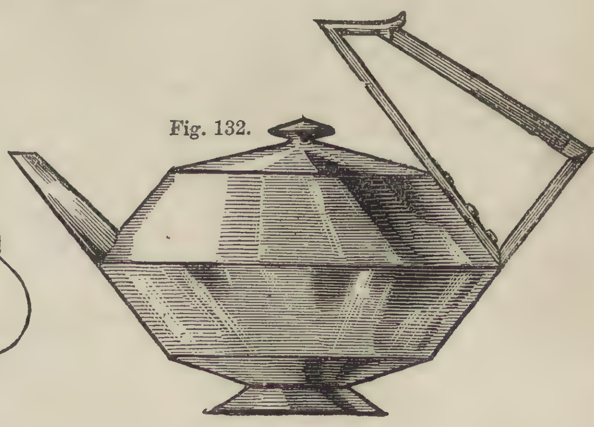


Fig. 132.

Fig. 124 would pour when in the position shown in Fig. 125, but see how far the hand that holds it would be to the right of the centre of gravity, which distance is of great disadvantage, as it causes the vessel to appear much heavier than it actually is, and requires a much greater expenditure of force in order to put it to its use than is necessary were it properly formed.

The law governing the application of handle and spout to vessels is this, and the same principle applies whether the vessel be formed of metal, glass, or earthenware:—Find the centre of gravity of the vessel, which can easily be done by letting a vertical line drop over it when placed in two different positions, as in Figs. 126, 127, and where the two vertical lines intersect, as in *a* in Fig. 128, is the centre of gravity. The position of the handle being fixed on, draw a line through the centre of the handle, and continue it through the centre of gravity of the vessel. The spout must now be at right angles to this line. If this be the case the vessel will pour freely, while the handle is just hung upon the thumb or finger of the person desiring to pour from it, as may be seen from Figs. 129, 130, in which the straight line A, passing through the centre of gravity *a*, is at right angles, as it should be, with the straight line passing through the spout.

This law, if obeyed, will always enable liquid to be poured from a vessel without its appearing heavier than it actually

is, but it will be seen that the shape of the vessel must be considered so that the spout and handle can bear this relation to each other, as in Figs. 131, 132. Some shapes will not admit of it, so they must be avoided, as may be seen by examining Figs. 124, 125, which show a tea-pot of faulty shape in this respect.

A consideration of this law shows us that the handles of jugs, those formed of silver, of glass, and of earthenware alike, usually have the handles too high; but in this respect things are much better than they were a few years back. Now we somewhat frequently see a jug with the handle in the right place, while some years back we never did. Silver jugs are now the most generally faulty in this respect, and such mistakes as the wrong placing of the handle or spout of a vessel result only from ignorance, for no man knowing the law would violate it (Fig. 133).

It is unnecessary that I say more respecting shape and the general construction of silver and gold vessels, except to remark that if figures or other ornaments are beaten up on the surface of a vase, they must not destroy or mar its general contour.

Iron is not used with us as it should be. Not only is the effect produced when it is inlaid with silver and other metals excellent, but by this mode of work our art creations are greatly preserved, for the iron is valueless, and the labour of removing the small quantity of precious metal inlaid would be so great as to render the gain inadequate remuneration for the time consumed in collecting it.

M. Christophle, of Paris, and also M. Barbedien in a lesser degree, have commenced to inlay copper vessels with silver, and some of their works are very beautiful; and the Japanese have from an early time inlaid silver in bronze. This inlaying of silver into copper is a step in the right direction, and should be encouraged by all lovers of art. The Indians not only inlay silver in iron, but also gold in silver; and the firmness and intricacy of some specimens of this inlaying are truly marvellous.

By the process of enamelling, colour can be applied to metal, and of all arts this art of enamelling produces works which are most lovely; at least, if the best works of enamel do not surpass those produced by any other manufacture, they are, at least, equal with the works of the highest excellence. Transparent enamels are in some cases very beautiful, but they do not generally compare with the opaque enamels, such as were largely used by the Chinese about a hundred and fifty years back, and by the Japanese, or those now so skilfully applied by Barbedien, the Algerian Onyx Company, and Christophle, all of Paris.

Chinese *claisonné* enamel vases may be seen at the South Kensington Museum, and here you may also find one or two small pieces of Japanese enamel, as well as one or two grand specimens by Barbedien, of Paris.

The Chinese enamels have most frequently a light blue (sort of turquoise) ground, but they occur with both red, white, green, and yellow grounds; while the ornament is of mixed colours, but generally with light yellow-green, deeper blue-green, or dark blue prevailing in it.

The Japanese enamels have a lower tone of colour-effect than the Chinese, and the work is finer and the colours more mingled, while the modern French enamels are full in colour, and are yet rich and subdued in general effect—some of them, indeed, are most beautiful works.

Elkingtons, of Birmingham and London, have also produced some beautiful things in this way, but not in the quantities that Barbedien has. I most strongly advise the art-student to study these works in enamel.

Niello work is a form of enrichment applied to metal not in general use; it is a difficult process. Silver snuff-boxes and pendants for watch-chains with a niello pattern upon them are not uncommon in Belgium and Russia, the niello pattern appearing as dark lead-pencil work upon the silver. Some niello work is very quiet and beautiful, but much need not be said respecting it.

Jewels may be inserted in metal, but if this is done they should be somewhat sparingly used, even in the most costly of works, for if they are abundant they produce mere glitter, and the aim of the ornamentist must in all cases be the production of repose.

FARMING AND FARMING ECONOMY.—IX.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

BARLEY—OATS—RYE.

LAWSON describes twenty kinds of barley, all referable to the following four species: *Hordeum distichon*, two-rowed barley, comprising ten varieties; *H. vulgare*, four-rowed barley, represented by eight varieties; *H. hexastichon*, or six-rowed barley; and *H. zeocriton*, fan, spratt, or battledore barley—the two last having each one form only. The finer sorts all belong to *distichon*, while *vulgare* and *hexastichon* are found as hardy, coarse cereals, in northern latitudes or high exposed situations where wheat cannot be depended upon.

Common Two-rowed or English Barley.—Ears three to four inches long by one-third of an inch broad; containing 28 to 30 grains, not closely set on the rachis; awns extending about the length of the spike beyond its point.

Chevalier Barley.—Ears resemble the last, but contain two to four more grains; grain rounder, plumper, and superior to last; eight to ten days later in ripening; weight from 56½ to 58 lb. per bushel.

Annat barley is the produce of two selected ears picked from a field of Flaw Craig Farm, Carse of Gowrie, in 1830, and subsequently propagated by Mr. Gorrie, of Annat Garden. Grain rounder, plumper, and heavier than the preceding varieties.

Lawson also describes *Dunlop, Stains, Golden or Italian, Chancellor, and Royston* barleys, and black and naked varieties, in which last the grain may be separated from the chaff.

The four-rowed barleys include common *Bear, Bere or Barley-big.* This variety has an ear 2½ inches long, containing about 60 grains; grains pointed, or tapering to both ends; awns about 3½ inches long; cultivated chiefly in the Highlands of Scotland, and in the Lowlands on exposed, inferior soils.

White-rowed winter barley has thicker and rather longer ears, grain larger, skin thicker, and coarser than the last: sown in autumn, and is earlier than any spring variety.

There are also Square, African, Tangier or Morocco, Bengal, a black, and two naked varieties of four-rowed barley.

Six-rowed white winter or Pomeranian barley has six equidistant and distinct rows, the lower grains nearly at right angles with the rachis, awns in consequence much spread. It is the coarsest kind of barley cultivated, but is hardy and prolific.

Putney, fan, spratt, or battledore barley (*H. zeocriton*) is characterised by a short ear, very broad at the base; grains standing out from the rachis as in the last; awns spread much to both sides; very much resembling *H. hexastichon* except in the numbers of rows. Not widely cultivated.

PLACE IN ROTATION.

Barley occupies a leading position upon all light and medium soils. It usually follows a root-crop, consumed upon the land by sheep. A rich condition of soil, induced by a liberal use of purchased food, is inconsistent with the production of the finest samples of barley. Accordingly, some take this crop after wheat, so as to ensure a higher quality of produce.

Turnips being required for folding purposes up to May, the sowing of barley is often delayed to that time. When the weather is genial, such late sown barley may give a large return, but too often the dry character of this part of the year causes a rough, cloddy condition of soil, unfavourable to the development of barley. Hence in such cases it has been recommended to take white turnips after such late swedes, or a second root-crop, which will be fed off in the autumn in time to be followed with wheat, afterwards to be succeeded by barley. This plan, which gives two root-crops and two grain-crops in four years, avoids risk, and ensures better malting barley.

PREPARATION OF GROUND, ETC.

The sheep-fold may be looked upon as the leading feature in all barley-growing districts. As soon as the sheep have cleared a sufficient space for tillage operations, the land should be ploughed about three inches deep. This ought to be done as early as possible, so as to obtain the ameliorating influences of frost upon the land. The best conditions of soil are a fine top and a firm bottom, and this is best obtained by early, shallow ploughing, followed by harrowing. Another advantage of a fine surface is that weeds spring rapidly, and are destroyed by harrowing at sowing time; whereas, if ploughing and sowing proceed together, the charlock, poppies, and other seedlings

appear with the young barley and prove troublesome. The plough is occasionally relinquished for the cultivator in preparing land for barley with the view of securing the condition of soil and subsoil already indicated. Barley may be sown as early as the middle of February and as late as the latter part of May. March and April are both good months, but generally the largest crops and longest straw are obtained after early sowing. The seed is deposited by the drill in rows 8 or 9 inches apart, and at the rate of 2½ to 3 bushels per acre. The seed is not "pickled" previously to sowing, as in the case of wheat. No after cultivation except rolling is required.

HARVEST.

Barley being required for malting is allowed to ripen more thoroughly than wheat. If it were principally used for grinding into flour, the same rule of early cutting would apply to it as is found so desirable in the case of wheat; but uniformity of germination or sprouting is not obtained unless the grain is ripe when it is cut, hence the difference in practice. Barley is cut by reaping-machines or scythes, when the heads are bent over and the grains are hard. It is very often carted loose or untied in the south of England, but in the north and in Scotland it is bound into sheaves. More care is required in harvesting and preparing barley for market than wheat. The malt-tax, which is looked upon by most farmers as one of their greatest grievances, tends to exaggerate the difference in price between the best and second-best samples of barley. The same tax has to be paid on both; therefore, it is advisable to buy first-rate barley, and pay the tax upon it, rather than inferior samples with the same burden. Hence a great demand for top samples, and comparative neglect of those of second quality. Barley may be "put together" in a rick too early, and become bitter and high-coloured from heating; it may become dry (flinty) by too long exposure to the sun; it may be injured by rain; or it may suffer from imperfect threshing and dressing machinery. Any of these causes may result in a considerable reduction of price; and much careful management is required in order to bring a "well got up" good sample into the market.

Barley requires to be "hummelled," or deprived of its awns, after it has been threshed. This is effected by a special apparatus attached to the threshing machine, which may be described as a long cylindrical box placed across the machine, one end being higher than the other. In the centre is a spindle turning rapidly by means of a strap and sheaf. Upon this spindle a number of radiating, blunt knives are spirally attached from one end to the other, and as these revolve they cut off the awns of the barley, which, entering at the higher end, gradually passes through the "hummeller" into a winnowing machine, where the awns are blown away. Barley may be deficiently hummelled, in which case it will weigh badly in the bushel, and be displeasing to the eye; or it may be too closely dressed, and thus injured for malting. A bruised or broken corn will become mouldy upon its broken surface during the malting process.

OATS.

All our cultivated oats belong to two species, *Avena sativa* and *A. Orientalis*. Besides these, there are *A. nuda* and *A. brevis*, neither of which are grown in this country. The first two species comprise upwards of thirty-two varieties, of which thirty belong to *sativa*. The two sorts of *Orientalis* are known as white and black Tartarian oats, and are characterised by great length of straw, a long secundate, or one-sided panicle, awned grains, and thick, not very well filled husk. They are light in the bushel (39 lb.), but yield largely, and furnish good food for work-horses. Both are suitable for poor, exposed soils, where the finer classes of oats do not succeed.

The varieties of *A. sativa* are generally well marked. They are conveniently divided into early and late, and among the former the following are the best known:—

The *potato oat*, discovered in a potato-field in Cumberland, in 1788. Panicle spreading on every side, but rather compact and regular; straw inclined to be short; grain white, short, plump, and weighing as much as 46 lb. per bushel; adapted for good land.

The *Hopetown oat*, raised by Mr. Patrick Sherriff, of Mungoswells, East Lothian; ripens a few days earlier than the potato oat; not so liable to be blown out; straw longer and stronger; panicle more spreading; grain rather more awned and a shade browner in colour; and distinguished by a small reddish mark in the centre of the front of the grain.

The *Sherriff oat* is another of Mr. Sherriff's varieties; its chief point of excellence is its earliness. It is thick in the skin, small in the grain, and light in the bushel. This variety is known in Kelso market by the *sobriquet* "make him rich."

The *Sandy oat* was found by A. Thomson, herd-boy to Mr. Pirie. It is strong in the straw, and liable to blow out. The straw assumes a fine golden colour some days before the crop is fit to cut; the grain is small, and resembles the potato oat. It is useful for soft, peaty soils. The *early Angus* is nearly as early as the potato oat, and less liable to be blown out.

The *Poland oat* much resembles an inferior sample of potato oats. The *Canadian oat* is very similar to the above. Besides these, the Kildrummy, Barbachlaw, Friesland, Birley, and Cumberland early are all well-known varieties. The Dun or winter oat is very hardy, and may be sown in the autumn. It is characterised by a tawny-coloured grain, and is very early in coming to maturity. The common Dun oat is a rather late variety adapted for poor elevated soils.

CULTIVATION OF OATS.

In the southern, eastern, and western counties oats follow roots fed upon the land; and in the north of England and Scotland they are usually taken after one or two years' grass (see Northumberland Rotation, Vol. II., page 262). Oats are hardy, and grow to greater perfection in the north than in the south. The large choice of varieties furnish suitable kinds for every class of soil, from the rich land where potato oats thrive, to the rough fells on which the Tartarian oat furnishes an abundant supply of straw and grain. The preparation of root-land for oats is similar to that for barley. When the crop follows lea, the land is ploughed about January, allowed to lie until a stale furrow is secured, drilled or sown broadcast, and well harrowed. March is the best month for sowing oats, and from 2½ to 3 bushels of seed will ordinarily be sufficient. Oats are as a rule sown more thickly than either wheat or barley. Rolling is all the after-cultivation they receive, unless we include under this head a top-dressing of guano or some ammoniacal salt.

No crop derives more benefit from change of seed than oats, and it has been shown that there is some advantage in mixing two varieties together for seed. Mr. Finnie, of Swanstown, obtained the following results per acre from different kinds of oats sown separately, and mixed upon equal portions of land:—

Potato oats	bushels	74	Dun oats	bushels	76
Hopetown	„	65	Sandy oat (unchanged seed)	„	56
Early Angus	„	77	Sandy oat (changed seed)	„	61
Kildrummy	„	77			

When mixtures of two varieties were employed—

Hopetown and Kildrummy gave	85	bushels per acre.
„ and Sandy	80	„ „ „
„ and Early Angus	76	„ „ „
Potato and Early Angus	66	„ „ „
„ and Sandy	66	„ „ „

Oats, of all cereals, should be cut early—(1) because they are apt to blow out; (2) because oat-straw is a valuable fodder, especially when cut soon. They are cut with the reaping-machine, tied up, stacked, and carried as in wheat harvesting; they require more time to dry than other cereals. In the North farmers "gaitan" oats, or set up individual sheaves tied loosely near the head, and with the butt-end spread out to give support. This allows a free circulation of air through the gaitans, and when sufficiently dry they are tied up into ordinary sheaves and carried.

RYE.

Secale cereale is represented by common rye and St. John's Day rye. Both are used extensively as forage crops (see Vol. III., p. 27). They are also, to a limited extent, grown for seed. Rye is suitable for light sandy soils, and in the north of England it is sometimes mixed with wheat, and grown under the name of "maslin." This mixed crop occupies soils which are considered too light for wheat; it ripens uniformly, and is sold for a price but little below that of ordinary wheat samples. The St. John's Day or Midsummer rye differs from common rye in being later and in producing longer straw and ears, and more foliage.

The cost of producing the three foregoing crops may be approximately stated as follows:—

	s. d.		s. d.		s. d.		s. d.
Ploughing	8 0	Drilling	1 10	Rolling	0 9	Threshing	8 0
Harrowing	2 0	Seed	12 0	Harvesting	12 0	Winnowing	5 0

Winnowing includes cost of marketing. The whole amounts to £2 9s. 7d., to which £1 15s. may be added for rent, rates, etc., making a total of £4 4s. 7d.

An average crop of barley on fair land, well farmed, will yield from 35 to 40 bushels of grain, and from 60 to 65 bushels is a heavy crop. Oats yield very differently, according to variety. Tartarian oats will produce 50 to 60 bushels, which is a moderate crop, up to above 100 bushels. An average crop of potato oats ranges from 45 to 50 bushels, and a maximum crop 80 bushels per acre.

MINING AND QUARRYING.—XVII.

BY GEORGE GLADSTONE, F.C.S.

TIN (*continued*).

SMELTING—REFINING—PROPERTIES OF TIN—USEFUL APPLICATIONS—BRONZE: ITS PREPARATION AND USES—PEWTER—SOLDER—USE OF TIN IN DYEING.

THE whole of the tin ore raised in Cornwall and Devonshire is smelted within those counties, in compliance with an ancient privilege granted some centuries ago.

The process is a comparatively simple one, the metal being easily reduced from its oxide; but it has to undergo subsequent operations before it attains to its purest condition. The smelting is performed in a reverberatory furnace, the ground-plan of which is shown in Fig. 10, where two basins, A A, for the reception of the molten metal, are seen at the side of the furnace. The bridge is at B, the charge is introduced at C, and it is worked by the furnace-man through the opening at D. The bridge and sole are hollow, to allow the air to circulate freely under them for the sake of modifying the heat to which they are exposed.

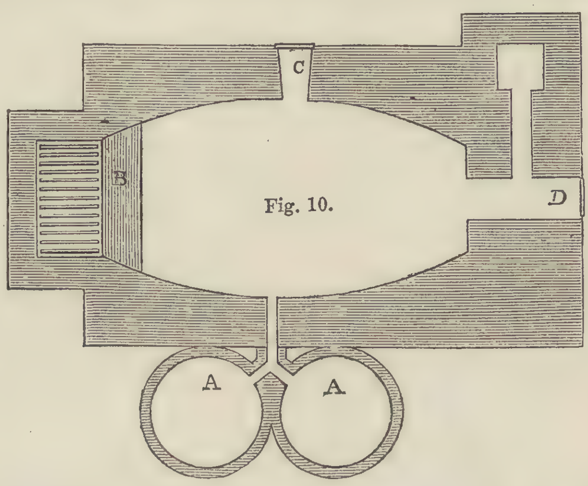


Fig. 10.

A charge consists of about 20 cwt. of ore, which contains on an average from $62\frac{1}{2}$ to 65 per cent. of metallic tin: this is mixed with about one-seventh of its weight of powdered culm, and a little slaked lime. Before being introduced into the furnace they are intimately mixed together, and slightly moistened with water, because if they were passed in a dry state, such a fine powder would be blown up the chimney by the strength of the draught. The door is then shut and luted closely, and the temperature of the furnace is gradually raised, for six or eight hours, after which the door at D is opened, and the molten mass is stirred to facilitate the separation of the scoriæ from the metal. As soon as the reduction appears to be complete, the scoriæ are raked out through the same aperture. That which is uppermost is thrown away as valueless; the next batch usually contains about 5 per cent. of tin intermixed with it, and is sent to the stamps that the metal may be separated by the means previously described; the scoria which still remains contains so much tin as to be worth smelting again. All this being removed as far as possible at this stage, the channel leading to the basins, A A, is opened, and the tin flows into them, the floor of the hearth being made to slope slightly downwards for the purpose. Any scoria remaining mixed with the metal rises to the surface, as it is of less specific gravity, and is then removed; the metal is lifted out with ladles and poured into moulds to cool. The scoria of the second class, after being stamped and washed, is added to that taken out afterwards, and this mixture is called "prillion." It is smelted by itself, and makes an inferior metal.

The tin thus prepared is not, however, pure enough for use, and has therefore to be refined. The furnace used in this operation is similar to that above described, except that it has only one basin instead of two. This is usually about 4 feet in diameter, by 2 feet 8 inches in depth, and is made of iron with a fire-place underneath it, as it is necessary to keep the metal in the basin liquid for some time. The ingots of tin from the smelting-house are piled up in the refining furnace near the bridge, and as they melt the liquid metal trickles down, and passes out into the basin, fresh ingots being inserted as the first batch melts away, until there is sufficient to fill the basin. The impurities, principally consisting of iron, which do not melt so readily as tin, remain behind on the hearth of the furnace.

Billets of green wood are now forced into the molten tin, and kept there for about three hours. The heat causes the evolution of gas from the green wood, which, in escaping, produces a brisk ebullition of the metal, and a quantity of froth, which collects on the surface. This froth consists, for the most part, of the imperfectly reduced oxides, and is therefore skimmed off from time to time, and returned to the furnace. When the boiling has continued for the time above named, the billets are withdrawn, and the metal is allowed to settle. The purest metal will now be the lightest, and will therefore occupy the upper portion of the basin; this is ladled out and poured into ingot moulds to cool. The ingots first made will consist of the best quality, and are called refined tin; those which succeed, and which are sufficiently pure for ordinary purposes, are sold under the name of block tin. What remains at the bottom of the basin will contain too many impurities to yield a merchantable article, and has, therefore, to undergo further treatment.

The residues which are left on the hearth of the refining furnace are subsequently melted by increasing the temperature, and the alloy is run out into another basin, where, after awhile, it separates into two portions; the more fusible, consisting mainly of tin, is poured into moulds, and is refined a second time; the remainder, which adheres to the sides and bottom of the basin, is rejected as not worth further treatment.

The quantity of refined metal produced is about 9 per cent. short of what it should be theoretically; which, considering the high value of the article, is a serious item; it is a matter worthy of study, whether some of this loss cannot be prevented, or subsequently recovered.

Pure tin is a brilliant white metal, which is only very slightly acted upon by the air or by water, at an ordinary temperature, so that it will retain its brilliancy unimpaired for a long time. It is too soft, however, to be used alone in the manufacture of utensils, as in order to secure the necessary strength such a thickness of the metal would be required as to seriously enhance the cost; for such purposes it has, therefore, a foundation of some inferior metal, such as iron, the tin merely forming an outer coating; or it is alloyed with a cheaper metal, such as lead, constituting pewter. In respect of hardness, tin occupies an intermediate place between lead and pure gold; in conductivity for heat it is superior to lead, but is inferior to zinc, iron, copper, or the precious metals. Its specific gravity is 7·29. It melts at a comparatively low temperature, 230° Centigrade, equal to 446° Fahrenheit. When exposed to a red heat it absorbs oxygen from the air with avidity, forming the peroxide of tin, which is a whitish-coloured powder. The pure metal is very malleable, so that it can be beaten out into foil of only $\frac{1}{1000}$th of an inch in thickness, but it is not very tenacious. It is of use in the arts, both in a state of solution and as an oxide; and it plays the part also of an acid, forming valuable compounds with the alkaline metals.

In considering the various appliances of tin, we will first take the principal alloys into which it enters, their preparation and characteristics.

Bronze is an alloy of copper and tin. Historically it is probably the oldest of all compound metals, and was perhaps used at almost as early a period as any pure metal. The collections of Egyptian, Greek, and Roman antiquities and coins in the British Museum furnish innumerable specimens of this

alloy. As modern examples of its use we may mention cannon (incorrectly called "brass guns"), bells and gongs, our new (again often mis-called "copper") coinage, the statues and lions in Trafalgar Square, etc. etc. In character it differs widely from either of its constituents. The product is hard, tenacious, and slow to tarnish on exposure to the air. In respect of fusibility it occupies an intermediate place between copper and tin; and the same applies to its density, though this is somewhat greater than the mean of its components. This anomaly increases with the proportion of tin employed; thus an alloy consisting of equal parts of the two metals would theoretically have a specific gravity of 8·09, but it is found by experiment to amount to 8·79.

In making bronze castings the proportions of the ingredients are varied according to the nature of the work in hand. For coins and medals about 10 per cent. of tin is used, a small quantity of zinc being also sometimes added. The object is to make a sufficiently hard alloy, so as to withstand a considerable amount of wearing, and yet one which will receive a sharp and good impression under the die.

A compound largely used by engineers consists of copper, tin, and zinc, the tin being generally in larger proportions than above named. 18 per cent. of tin to 2 per cent. of zinc and 80 per cent. of copper produces a very hard metal: by slightly increasing the copper at the expense of the tin, a more malleable compound will be obtained. A portion of the zinc may also be replaced by lead. Another quality of engineers' metal, which is advantageously employed in some parts of machinery, consists of 87 per cent. of copper, 12 per cent. of tin, and 1 per cent. of antimony.

Brass guns, as they are commonly called, are usually made of an alloy containing about 89 per cent. of copper and 11 per cent. of tin. In view of the great strain to which the metal is necessarily subjected, much care has to be taken in the casting of them—firstly, as to the purity of the materials, and secondly, as to the homogeneity of the alloy. The smallest admixture of sulphur or arsenic will tend to make it brittle, and therefore liable to burst when being fired off; a very small admixture of lead will make too soft a metal, and one liable to be rapidly acted upon by the heat generated in the explosion of the gunpowder. In making a bronze casting of the size of a cannon, it is a matter of no little difficulty to produce a similar alloy throughout, as the tin is lighter than the copper and has a tendency to separate more or less from it; so that it not unfrequently happens that the upper part of a large casting will contain a greater relative proportion of tin than the lower part. This will also affect the strength of the gun, and is therefore by all possible means to be avoided. The metal is melted in reverberatory furnaces, so arranged that the flame shall not produce an oxidising effect upon the charge; and the furnace is raised to a high temperature. When the metals are quite liquefied, the whole is well stirred up with a long wooden pole, which produces an ebullition, as in the refining of tin, and causes an intimate mixture of the two ingredients. When the charge has been sufficiently poled, the furnace being still kept up at its full heat, the plug is withdrawn, and the molten mass runs down the channel into the moulds prepared to receive it.

In casting statues and the like, it is not so absolutely important to ensure the purity of the materials and the thoroughness of their mixture, as the weather test is the principal one which they have to stand. Even in this case, however, attention should be paid to these points, as copper suffers rapid waste by exposure, and the good effect would be lost if one part of the figure were to show more oxidation than another. Many old statues will furnish proofs of bad melting, some portions being honeycombed and eaten away by weathering, while others are comparatively fresh and sharp. The well-known column of the Place Vendôme at Paris is a notorious example of the imperfect mixture of the tin and copper, the relative proportions in some segments being widely different from what they are in others. Though bronze, whatever the proportions of the ingredients, is always more fusible than copper, it is not by any means easy to make a very large casting which shall be satisfactory in all respects; and the plan is therefore often adopted of making the figure in separate segments, and afterwards uniting them by means of a hard solder, such as will be produced by a mixture of three parts of zinc to four of copper. The colossal lions at the foot of Nelson's Column were cast in separate pieces, and the lines of junction may be discovered on a close examination, though they are not at all perceptible when looked at from an ordinary distance. Another advantage in the adoption of this plan consists in the saving of material, as such figures are always made hollow.

Bronze is used for making bells and gongs on account of the sonorousness of this alloy. The most approved proportions are 78 per cent. of copper and 22 per cent. of tin; 69 per cent. of copper and 31 per cent. of tin also makes a very hard and sonorous material; but the proportions and even the constituent metals are often varied, a very common mixture being 77 per cent. of copper to 21 of tin and 2 of antimony. Zinc and lead are frequently introduced at the expense of both the principal ingredients, to make them more readily fusible, but the fineness of the tone is sacrificed at the same time. In bell-founding the metal is melted in a reverberatory furnace similar to that described in casting cannon, but the whole of the tin is not introduced at once, about one-third being added after the rest of the alloy has been thoroughly liquefied.

Speculum metal, used in the construction of reflecting telescopes, consists of an alloy of tin and copper in the proportion of two-thirds of the former to one-third of the latter. It is white, hard, and takes a very high polish: 73 per cent. of tin to 27 per cent. of copper also makes a very white and suitable metal for this purpose.

Another series of very useful alloys of tin is comprised under the general name of pewter; but they are distinguished among themselves by other and sometimes higher sounding names. Familiar instances of the use of pewter are beer pots and the common liquid measures. The former should consist of 83 per cent. of tin and 17 per cent. of antimony; but lead is very often used in part substitution of the latter metal, though the alloy suffers in respect of hardness in consequence. The commonest pewter contains 80 per cent. of tin, the remainder being lead. When so large a proportion of the last-named metal is used, there is some danger of its affecting injuriously the liquids which may be put in the vessels, especially if they should be at all acid. A harder pewter, used for making dishes, is obtained by the addition of a little copper.

The Britannia and Queen's metals, which are largely employed in the manufacture of coffee-pots and the like, are also different varieties of pewter. The former is a compound of copper, zinc, tin, antimony, and bismuth, the relative proportions of which differ considerably according to the fancy of the manufacturer. The latter consists principally of tin, with a little antimony, bismuth, and lead. In both cases the alloy is moderately soft, and fusible at a comparatively low temperature. Most of the utensils made of these are cast in brass moulds. These are made in separate pieces, fitted together with great nicety, and held firmly in a frame. The interior surface of the mould is rubbed with oil, or some other composition which shall prevent the molten metal from sticking to the brass. When cool the mould is pulled to pieces, and the vessel inside only needs trimming and polishing. Many hollow vessels are made on a wheel upon a principle somewhat analogous to that on which a potter forms cups and vases, only in this instance the instrument which fashions them is made to revolve and the sheet of metal is pressed against it; the body being thus formed, if handles, feet, or spouts are to be added, they are made separately, and then soldered on with a fusible alloy of tin, bismuth, and lead.

Tin is an important ingredient in many varieties of solder. That used by pewterers consists of the metals above named in variable proportions, according to the character of the work for which it is required. 50 per cent. of tin to 25 per cent. of lead and an equal proportion of bismuth form an approved mixture; at other times 33 per cent. of tin to 45 per cent. of lead and 22 per cent. of bismuth are employed in preference. Plumbers use a combination of tin and lead: two-thirds of the former to one-third of the latter forms a solder which has a melting-point of about 350° Fahrenheit; a mixture of one-fourth and three-fourths respectively makes a less fusible alloy, as it only melts at about 500°. The most fusible of all the compounds of these two metals is a solder composed of 60 per cent. of tin to 40 per cent. of lead, which melts at 334°; whether the proportion of either the one or the other constituent be increased, the melting-point will rise, though the advance will be the more rapid if the increase be on the part of the lead. The solders

containing bismuth are still more fusible; an alloy formed of equal parts of the three metals will melt at 254° Fahrenheit; and if the tin amount to 45 per cent. and the remainder consist of lead and bismuth in equal proportions, the melting-point will be as low as 202°, or 10° below the boiling-point of water.

Tin is also an article of great importance to dyers. Several of the solutions of this metal, which are used by them as mordants and for brightening colours, have been already referred to in Articles II. to V., inclusive, of "Chemistry applied to the Arts," which treat of dyeing and calico-printing. Those in most general use are the chlorides of tin; more rarely the acetates and oxalates. In combination with the alkaline metals, as stannate of soda or potash, it is also of much service in fixing vegetable dyes. The chlorides are made by dissolving the purest grain tin in hydrochloric acid, or a mixture of that and nitric acid. The tin should not be all put in at once into the acid, lest the action and heat evolved should be too rapid, the best solution being that which is prepared most slowly and with the least evolution of fumes. They are used in producing scarlet with cochineal. The stannates, which are prepared by decomposing the perchloride of tin with an excess of caustic alkali, are much used in producing what are called by dyers "steam colours," the dye being fixed in their case by the oxidising action of the steam.

Some other applications of this metal, and those not by any means the least important, must be reserved for the next article.

SHIP-BUILDING.—VII.

BY W. H. WHITE,

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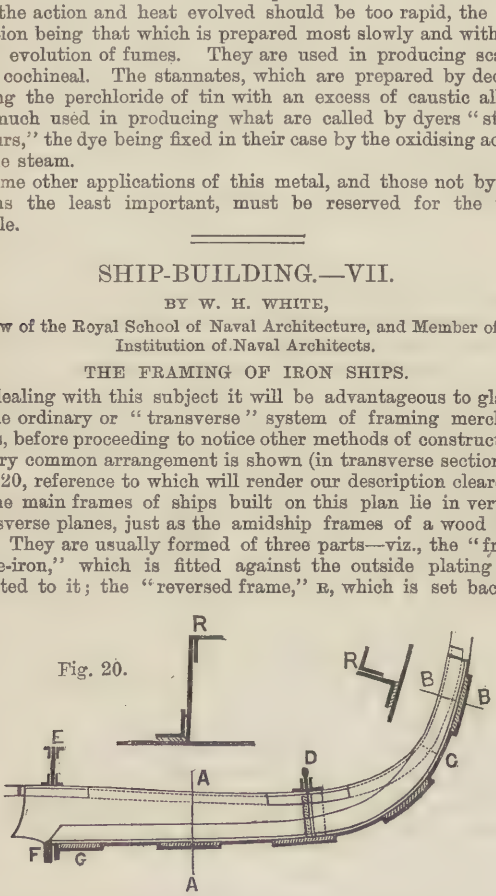
THE FRAMING OF IRON SHIPS.

In dealing with this subject it will be advantageous to glance at the ordinary or "transverse" system of framing merchant ships, before proceeding to notice other methods of construction. A very common arrangement is shown (in transverse section) in Fig. 20, reference to which will render our description clearer.

The main frames of ships built on this plan lie in vertical transverse planes, just as the amidship frames of a wood ship lie. They are usually formed of three parts—viz., the "frame angle-iron," which is fitted against the outside plating and rivetted to it; the "reversed frame," R, which is set back to

Fig. 20.



back with the frame angle-iron (in the enlarged section at B B) and rivetted to it; and the floor-plate, which stretches from side to side across the keel, and rises to the height C. At that point the frame angle-iron and the reversed angle-iron are separated, in order to admit the floor-plate between them, the former being connected to the lower edge of that plate, and the latter to its inner edge (as shown by the enlarged section at A A). From the floor-plate upwards the frame shown consists simply of two angle-irons set back to back and rivetted together, thus forming a double-flanged girder of great efficiency as compared with a solid timber of square section. It is usual to continue the reversed angle-irons on alternate frames up to the upper deck in all except small ships, and on the intermediate frames to end the reversed angle-irons further down. Into these details, however, we cannot enter.

The angle-irons for the frames and reversed frames can now be often obtained in one length from gunwale to keel; and consequently the labour and expense of welding or strapping pieces together is saved, while the strength of the frames is increased, and the combination of the parts is much simplified. Floor-plates are usually made of two or three pieces welded or strapped together, but even when thus formed they are connected in a manner that is superior to any joint made in the timbers of a wood ship's frame.

The simplicity and strength of such a combination as this cannot fail to be remarked, when it is compared with the elaborate arrangements unavoidable in a wood ship's framing. Neither in providing the materials, nor in shaping them to the desired form, nor in combining the various pieces, has the iron ship-builder any serious difficulty. The angle-irons are heated, bent, and bevelled with ease; the floor-plates are also readily fashioned; and the whole frame can be completely fastened together before it is raised. In fact, it is by no means uncommon to find the deck-beams also fastened to the frames before they are hoisted into place, and this operation can be performed without causing any considerable change of form in the frames—a good evidence of their individual strength.

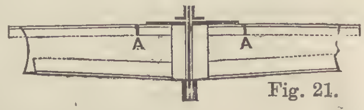


Fig. 21.

When treating of the transverse strains of ships, in a former paper of this series, it was pointed out that the resistance offered to any changes of form by the framing, plating, etc., at a cross-section, resembled that of a hoop-shaped girder. It may not be out of place here to consider this matter a little more closely, and to attempt to gain an idea of the respective uses of the parts of a frame, such as is shown in Fig. 20. In ordinary iron ships the distance between such frames would be something like two feet, so that we may suppose each frame to have as its duty the support of a foot-broad strip of plating on either side of it; which strip of plating, being rivetted to one of the flanges of the frame angle-iron, also helps to stiffen the frame. This mutual support is obviously an advantage as well as a necessity; but the use of the reversed frame, R, is a no less important feature, seeing that it provides an inner flange which would otherwise be wanting to the sections of the frame both at A A and B B. The outer flanges of those sections are necessarily large and strong for the reason just stated, and in order to fully develop their strength it is desirable to make the inner flanges also as strong as possible—in other words, to use large reversed frames.

The advantages resulting from the use of floor-plates are also obvious. By this arrangement great strength is provided, with a comparatively small expenditure of material, at a part of the ship where severe local strains as well as considerable bending strains may naturally be expected to occur. If, for example, a vessel takes the ground on her keel, and is otherwise unsupported, there must arise a severe bending strain tending to break the floors across; but their great depth would probably enable them to resist all such strains. The greatest intensity of strain would, of course, be experienced near the middle-line, and as the distance from the middle-line became greater the strain would diminish; hence we find ship-builders gradually reducing the depth of the floor-plates from the keel out to the bilges. Neither floor-plates nor reversed frames were used in some of the earlier iron ships, the frames of which were made up of single angle-irons; but the weakness and disadvantages of the plan soon became apparent, and led to the introduction of this present arrangement.

In the case illustrated by Fig. 20 the keel is formed of bar-iron, and marked F. This is the most common form of keel, and it is easily worked, the bars being rolled in considerable lengths, and connected either by scarfs or welds. Many other forms of keel have, however, been used, and much might be said respecting them, did space permit; it must suffice to refer to one or two only. In Fig. 21 an arrangement is illustrated which is often used, and is known as the "side-bar" keel. The floors do not cross the middle-line, as in Fig. 20, but are abutted against a continuous "centre-plate," which projects beyond them both above and below. On either side of the lower part of this plate a "side-bar" is fitted, and by means of through-rivetting the three thicknesses are formed into a keel. The floor-plates are connected to the centre-plate by means of short vertical angle-irons, and other means are generally taken to strongly connect the two sides. One of the most common connections in such cases is made by passing a

short angle-iron (such as A A in Fig. 21) through a slot cut in the centre-plate, and rivetting it to the floor-plates.

The strake of plating next the keel, marked G in Fig. 20, is usually termed the "garboard strake," and is a little thicker than the adjacent plating. Its lower part is flanged so as to fit against the side of the keel, and the garboards on both sides are secured by rivets passing through the keel. With the side-bar keel the garboards are similarly formed and fastened, and in this case great care is required in order to shift the butts of the side-bars, the centre-plate, and the garboards, and to avoid any specially weak section. With bar keels it is sometimes considered desirable to "rabbet" the garboard strakes into the keel, but this is a more expensive plan than that illustrated in Fig. 20, and is not so commonly used.

The only other kind of keel to which we shall refer is that known as the "flat-plate" keel. Hereafter an illustration of this will be given, and for the present it must be simply described as a plan which does away with the external keel, and substitutes for it a thick middle-line strake of plating. If in Fig. 20 we conceive the bar keel to be removed, and the garboard strake to be simply run across under the floors to the other side, a very good idea of the plan referred to will be obtained.

Whatever form of keel be adopted, it is usual to have the stems and stern-posts formed of solid bars or forgings. The simplest case is that where a bar keel is used, and the stem is strictly speaking a continuation of the keel, being, like it, formed of bar-iron. With either a flat-plate keel or the side-bar arrangement the same kind of stem would be used, but special means of connecting the stem with the keel proper would have to be devised. Much the same thing is true of the stern-posts, which are, however, obtained with more difficulty than the stems, being necessarily more or less elaborate forgings, according to the character of the vessel. In the case of a sailing ship or paddle-wheel steamer one post is sufficient, and it requires only to be so fashioned as to carry the rudder and be readily connected with the after-end of the keel, as well as with some portion of the hull of a ship. But in screw-ships two posts are usually fitted, and the forging required is much heavier and more elaborate. Still, even in such cases, it is customary to weld the whole into one solid mass before lifting it into place, and securing it to the keel.

Transverse framing is usually maintained throughout the whole length of iron merchant ships, with the exception of the stern proper. Very few iron ships have any cant-frames, nor is there the same reason for adopting such an arrangement as there is in a wood ship. The stern-framing of iron ships is of a very much more simple character than that of wood ships, and usually has for its base the aftermost square-frame, against which most of the canted stern-frames heel. It is scarcely necessary to add that even at the very extremities there is no difficulty whatever in bending and bevelling iron frames to the required form, and combining them with floor-plates; in fact, the only noteworthy differences between the framing at those parts and that amidships arise from the differences in the ship's form. As a consequence iron ships require no substitute for the deadwood of wood ships, nor have they usually anything equivalent to the apron or stemson commonly fitted in wood ships. Sometimes the bows of iron ships are strengthened by breast-hooks formed of plates and angle-irons. Such supplementary strengthenings, although of great value, are, however, not nearly so much required in iron as in wood ships; and it is no small advantage to the former class, that sufficient strength can be obtained in them without using large weights of material simply for the purpose of succouring and reinforcing parts that are in themselves weakly connected.

Towards the extremities of an iron ship the frame angle-irons often have considerable bevelling, and the rule is to place them so that their two arms, or flanges, may always contain an obtuse angle, or have what shipwrights term "standing bevelling." This rule is based upon the fact that angle-irons are found to be less weakened by opening them out from the right-angled condition in which the manufacturer supplies them, than they are when closed in, or worked to "under-bevelling." In order to carry it out, ship-builders place the frame angle-irons on the after-side of the floor-plates in the fore-part of the ship, and on the fore-side in the after-part. As the reversed frame is always placed on the opposite side of the floor-plate from that on which the frame angle-iron comes, it also has always a standing bevelling.

Without entering into further details, we must proceed to notice the provisions of framing usually made to strengthen an iron ship against *longitudinal* bending strains. It has already been pointed out that against such strains, which are by far the most severe a ship has to bear, transverse framing is altogether ineffective; and this fact will become clearer if the case of an iron ship is considered. At a cross section (such as is partly shown in Fig. 20) there must necessarily be a line of closely-spaced rivet-holes pierced in the outside plating, in order to secure it to the frame angle-iron, and such a line consequently forms an *unavoidably weakened section* along which the plating is more likely to give way than it is between the frames. Now if fracture occurred the transverse frame could obviously lend no aid to the plating, which could be helped only by some strengthening piece which *crossed* the weakened line. This is the great objection to the ordinary or "transverse" system of framing which we are considering. It was copied at first from the plan that had been long in use in wood ships, where it was a necessity. It has many advantages in point of rapidity of construction and cheapness, and it has the great advantage of being thoroughly understood on account of its long use. But its radical defect is that the main frames are available only against transverse strains, and ineffectual against the far severer longitudinal strains to which ships, and especially long ships, are subjected.

The earliest iron ships were comparatively short and small, so that the transverse system of framing answered very well in them; but as the lengths and sizes of ships have been increased it has become necessary to supplement the transverse framing by longitudinal pieces running throughout the length of the vessels. A very great variety of form has characterised the longitudinal strengthenings employed, but the common practice has been to fit the larger number from the turn of the bilge downwards, and to have only a few between the ending of the floors (C in Fig. 20) and the lower decks of ships. This arrangement has had the effect of strengthening considerably what we have termed in previous papers the "lower flange of the girder" formed by the ship, adding to its powers of resistance both to longitudinal bending strains and to local strains. As a matter of fact, ordinary iron ships much more frequently display weakness at their upper decks and top-sides than they do at the lower portions, so that there is reason to consider the strength of the bottoms as generally sufficient, although it may not be obtained in the best possible way.

The longitudinal strengthenings used are named "middle-line keelsons" (such as E in Fig. 20), "side-keelsons" (such as D), "hold-stringers," "bilge-keels," etc. Ordinarily the middle-line keelson in a ship with a bar keel is made to run along upon the inside of the reversed frames, as shown in Fig. 20, and underneath it a short piece of angle-iron is worked on the side of the floor-plate opposite to that on which the reversed frame is fitted, in order to strengthen the connection of the keelson and the framing. The I-shape shown in the sketch is commonly used, but "box keelsons," or keelsons formed of two angle-irons set back to back or having a bulb-plate between them, and other sectional forms are also employed. Similar differences exist in the forms of the side-keelsons used, as well as in the hold-stringers, the latter being very commonly formed of two angle-irons set back to back. There is obviously a great simplicity of workmanship in keeping all such strengthening *inside* the framing; but there is this serious disadvantage, that there is then no direct connection between the strengthenings and the outside plating which it is their great duty to succour. After much discussion the opinion seems now to be gaining ground, that it is preferable to sacrifice ease of workmanship to the other consideration, and to make at least some of the side-keelsons "intercostal," like D in Fig. 20, in order to directly connect them with the outside plating. On referring to the sketch it will be seen that the keelson D consists of short plates fitted *between* the frames or ribs (hence the name "intercostal"), of equal depth with the floor-plates at that place. The lower edges of these plates are directly connected with the outside plating by short longitudinal pieces of angle-iron; and their ends are secured to the floor-plates by other angle-irons. Their inner edges are overlapped by the lower part of a "bulb-plate" to which they are rivetted; this plate is continuous, as are also the two angle-irons connecting it to the reversed frames. Many modifications of

this arrangement will at once suggest themselves to one acquainted with ship-building, but in all of these modifications the same principle of direct connection between the keelson and the outside plating ought to be carried out. In some cases builders have sought by similar means to make a direct connection between the middle-line keelson and the bar keel, but this is less common. With a side-bar keel (such as that in Fig. 21) the centre-plate forms a continuous longitudinal strengthening, and obviously combines keelson and side-bars in a very satisfactory manner. In that sketch also is shown an example of what is termed a "flat-plate keelson," examples of which are frequently met with in ships with other than side-bar keels. It may be added here that in vessels with flat-plate keels it is by no means uncommon to have a centre through-plate (or "vertical keel"), and other middle-line arrangements, resembling in character those shown in Fig. 21, with the difference of the keels.

In a large vessel there might be two or more side-keelsons between the middle-line and the turn of the bilge, besides hold-stringers above that height. The minimum numbers and dimensions of these strengthenings are stated in the rules which guide private builders, but in some cases more are fitted than the rules require. Bilge or side keels are also commonly used in order to strengthen large iron ships, being formed much in the same way as the hold-stringers, but rivetted on the *outside* of the bottom plating. Such keels, besides strengthening the ships, help to check both rolling and lee-way, and in most cases these are the primary objects for which they are fitted.

By all these arrangements considerable longitudinal strength is given to the lower parts of ordinary iron ships; but in order that the material used in the strengthenings may be properly efficient, great care is required in arranging and fastening the butts or scarfs of the various plates and angle-irons. It is possible, as we have seen, when iron is used to join two pieces together so that they will resist either tensile or compressive strains, and this fact makes it easy to form strong longitudinal ties in an iron ship and to supplement the transverse framing. But if no care is taken to secure the butts and scarfs of the keelsons, etc., they become worse than useless, and there have been very many instances of such neglect. That they may be thoroughly efficient, all such longitudinal strengthenings must be made to approach as nearly as may be to *continuity of strength*, and not left in detached pieces or stopped short at bulkheads. In order to render our meaning plainer still, we will consider what would have to be done in arranging and fastening the butts of the continuous bulb-plate and angle-irons in the side-keelson D in Fig. 20. Here three pieces have to be combined, and indirectly associated with the strake of outside plating to which the intercostal plates are attached. We will suppose the butts of this strake of plating to be fixed, then it would obviously be advantageous to keep the butts of the keelson clear of the butts of the plating. No difficulty would be experienced in doing this, because the bulb-plate could be rolled in lengths, say twice as great as the outside plates, and so also could the angle-irons. Starting, therefore, from the butts of the outside plating, it would be easy to place the butts of the bulb-plate clear of them, or to make them "shift;" and having fixed the latter, to place the butts of the two angle-irons so as to give shift to each other, to the butts of the bulb-plate, and to those of the outside plating. This operation is what we have termed the *arrangement* of the butts; but it is also necessary to care for their *fastening*, and in the case considered all the butts of both angle-irons and of the bulb-plate too should be strongly secured by straps. The illustration is a very simple one, but it will serve to indicate the kind of work that has to be done in many more difficult parts of the work of ship-building, in order to secure good combinations.

TECHNICAL DRAWING.—LVIII.

GOTHIC STONEWORK.

DECORATED WINDOWS (*continued*).

THE window here given (Fig. 504) is a specimen of the flowing Decorated. An example of a simple character has been chosen, to enable the student to copy it without much difficulty. The divisions of the panes are therefore omitted, in order to show the centres from which the various curves are struck.

Towards the close of the reign of Edward III. the outlines of window tracery began to show a tendency to adapt themselves to the vertical bearings of the mullions, instead of branching off from them in flowing undulations. This, the death-blow to flowing tracery, and with it to Decorated Gothic, gave rise to a new variety, at present known by the name of the Perpendicular style. Here, however, as in the previous changes, the alteration was very gradual, consisting at first merely of the introduction here and there of a perpendicular member into a design in other respects flowing in character; and this vertical bearing of the mullions is the foundation of all Perpendicular tracery.

Circular windows, filled with beautiful tracery, are often met with in large structures. Windows in the shapes of squares,

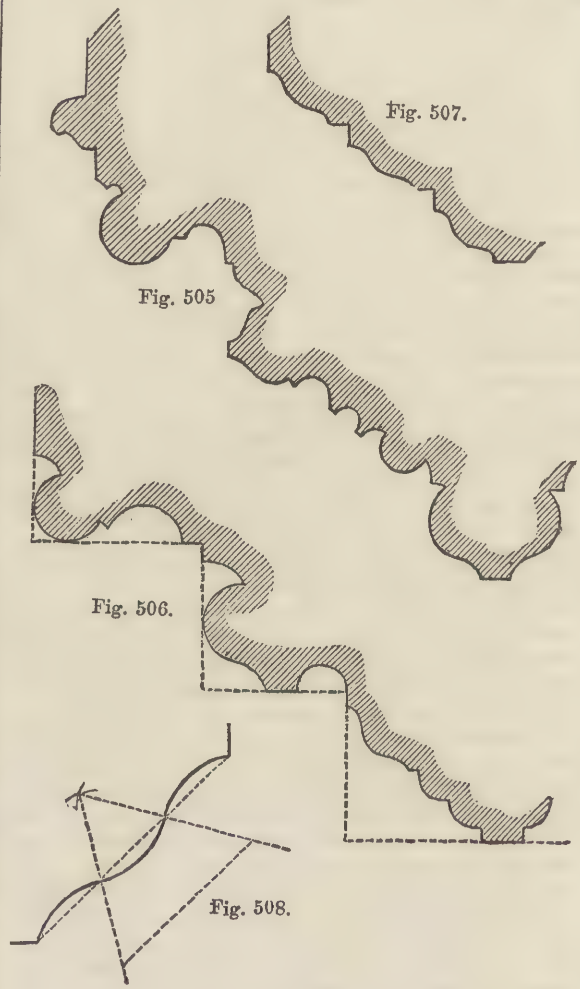


Fig. 507.

Fig. 505

Fig. 506.

Fig. 508.

trefoils, quatrefoils, spherical triangles, hexafoiled circles, etc., are also frequent, but are generally of small size, and are usually seen in subordinate situations, such as in clerestories, gables, etc.

DECORATED ENGLISH BUTTRESSES.

These are not in some instances easily distinguishable from those of the Early English period, for they sometimes consist merely of plain piers, with one or more slopes or set-offs, without any further decoration; but in many cases they may be known by being set diagonally at the angles of the buildings, whilst, as has already been stated, those of the preceding periods were set at right angles to the two walls. Even this, however, must not be taken as an absolute rule, for some Decorated buttresses are similarly placed. The distinctions will therefore principally lie in the mouldings, the finials, crockets, etc. In rich examples the faces are often recessed for niches,

which are surmounted by rich canopies, small buttresses, pinnacles, etc. The buttress seldom reaches above the parapet, unless surmounted by a pinnacle, which is mostly of an elaborate description.

The parapet is frequently used in the Decorated period, and is often pierced in various shapes—such as trefoils or quatrefoils—inserted in the spaces left on either side of an undulating moulding.

DECORATED ENGLISH MOULDINGS.

These are, as a rule, larger and bolder than those of the Early English period, and are arranged with a more studied regard to broad effects of light and shade. The somewhat monotonous similarity of numerous small members is no longer found, and the eye is at once arrested by two or three prominent forms, whose broad shadows produce the leading lines in a suit of mouldings, and divide the whole into masses, whilst numerous small mouldings produce a streaky effect. Fig. 505 is a section of the pier-arch of St. Oswald's, Chester, in which will be observed one prominent member in each order—a fine roll and fillet in the first; another differently set in the second; and a bold round and hollow in the third. So, also, in the pier-arch of the nave of the cathedral (Fig. 506), we have a remarkably bold roll and fillet in the second, and a roll and hollow in the third. "The effect of these," says the Rev. T. N. Hutchinson, and which the author has often observed, "is very striking when received in full sunlight." Fig. 507 is a section of the pier and arch moulding of one of the pier-arches, in Chester Cathedral, adjoining the central tower, and exhibits a form of moulding which is of constant occurrence in Decorated work. This is the "wave-moulding," or *swelled chamfer*. It is little more than an ordinary chamfered edge, with a slightly-sunk channel on each side, thus raising the middle portion into a curved or swelled form. The arch in question is of three orders, each chamfered with the wave-moulding. The curve of the wave-moulding is struck from the three points of an equilateral triangle (Fig. 508). A group of two or more wave-moulds, with intervening hollows, was a common and most beautiful Decorated arrangement.

Fig. 504.—WINDOW AFFORDING AN EXAMPLE OF THE FLOWING DECORATED STYLE.

This moulding was also of frequent occurrence in Perpendicular, though belonging to the former period; its presence alone is, in the absence of other criterion, nearly sufficient to stamp an example in which it occurs as Decorated.

The method of covering flat surfaces with ornamental patterns in low relief has been spoken of in connection with the Early English, and it continued to be extensively used in the Decorated period. One of the most beautiful diapers of the time exists in Canterbury Cathedral. The design is composed of a flower of six leaves in low relief, within a hexagonal compartment, the sides of which are formed by the sides of six spherical triangles, and are foliated within. A great number of other beautiful patterns in diapers were used in this style. The origin of the name has been a source of dispute: it is supposed to be taken from a kind of cloth worked in separate patterns, and which

was then, as now, much used under the name of *dyaper* or *diaper*, originally *d'Ypres*, the chief manufactory being at Ypres, in Belgium. Of this species of decoration, Mr. Brandon says: "It is a peculiar characteristic of pure Gothic that all mouldings, panelling, or sculpture were always sunk from the face of the work. Such an arrangement is the natural result of a style, a distinguishing type of which was *only to introduce ornament as an embellishment to construction.* Thus, a capital would naturally be corbelled from the pier, the better to carry the superincumbent weight; hence its subdivision into head mould, and bell and neck mould. Panelling resulted from a desire to enrich that which would otherwise have been a flat surface, and consequently was wrought out of the face already existing. A row of dog-tooth generally exemplifies very well how ornaments also were worked out of the block. As the debasement gradually crept in we find the contrary to have taken place."

SEATS OF INDUSTRY.—XXII.

PHILADELPHIA.

BY WILLIAM WATT WEBSTER.

THE story of the origin and growth of Philadelphia, the largest city in Pennsylvania and the second largest in the United States, is exceedingly interesting and instructive, and is in many respects peculiar and even unique. It is a striking example of the extraordinary influence that one or two energetic, philanthropic, and able men can, in certain circumstances, exercise over the fortunes of a town. Pennsylvania was originally colonised by Swedes, who settled there in 1638, under the protection of their native country. Previous to the conquest of the New Netherlands by Great Britain in 1664, considerable numbers of Dutchmen and Finlanders had also established themselves on the banks of the river Delaware. About eighteen years after this event, William Penn obtained a charter from Charles II. granting him proprietary and governmental rights over the province. During the years 1682 and 1683, large numbers of immigrants, chiefly members of the Society of Friends from Wales, arrived in Pennsylvania and purchased land. The foundation of a large town from the first formed a part of Penn's scheme of colonisation, and the rapidity with which he accomplished this undertaking was very remarkable, and probably unprecedented. In choosing the site on which Philadelphia stands, Penn showed great discrimination. The spot he fixed upon was a neck of land formed by the bending towards each other of the rivers Schuylkill and Delaware, about six miles above their junction. He justly described it as a situation "that seems to have been appointed for a town, whether we regard the rivers, or the conveniency of the coves, docks, and springs; the loftiness and soundness of the land and air;" adding that "of all places in the world" he remembered "not one better seated." In dealing with the Indians, Penn acted with praiseworthy prudence and justice. Notwithstanding his charter, he purchased the soil from them at an equitable price, and the young town in consequence seldom suffered from the hostility of the natives of the district. The policy then adopted was pursued by the Constituted Government after the American Revolution, when the State of Pennsylvania made additional purchases from the Indians. Philadelphia was also singularly exempt from other evils, such as scarcity of food, to which young towns placed in similar circumstances are usually subjected during the earlier years of their existence. By 1683 Philadelphia contained 357 houses, and three years later the number had been increased to 600. In 1684 the population was estimated at about 2,500. The town was formed on a well-defined plan, in which Penn is said to have attempted to realise the idea he had formed of ancient Babylon, and the existing city is, with slight modifications, built in accordance with the original design of its founder. In 1700 a Swedish church was built on the site of a wooden church which had been erected in 1677, five years before the settlement of the Welsh. The first American newspaper, the *Weekly Mercury*, was published at Philadelphia in 1719, and nine years later the *Gazette*, edited by Franklin, was established. There were 1,500 houses and 13,000 inhabitants in Philadelphia in 1744, and five years later, Dr. Benjamin Franklin, next to its founder the greatest benefactor of the city, and others carefully counted the houses, which were found to number 2,076, exclusive of 11 churches. In this same year, 1749, about 20,000 immigrants, one-half of whom came from Germany, and the other half from the north of Ireland, landed at Philadelphia. During the revolutionary wars, the city was the scene of several important events. There the Declaration of Rights was adopted and promulgated in 1774, and the Declaration of Independence was issued from it in 1776. In 1777 it was occupied by the British forces under General Lord Howe for nine months, and at that date its population amounted to 21,767. The convention that drew up the constitution of the United States met in Philadelphia in 1787, and in 1790 the first Congress under this Constitution assembled there. From that year till it was supplanted by Washington in 1800, Philadelphia was the capital of the Union, and it continued to be the most populous city in the American continent, till it was outstripped by New York, about a quarter of a century after the Declaration of Independence. The State Legisture also removed to Harrisburg in 1800, so that Philadelphia ceased to be the political capital of Pennsylvania at the same time that it ceased to be the seat of the General Government.

In 1810, Philadelphia contained 96,664 inhabitants; in 1820, 119,325; in 1830, 167,811; in 1840, about 200,000; in 1850, 340,045; and in 1860, 562,529. At the present time the city occupies about 12 square miles of ground, and is about 5 miles in length by about $3\frac{1}{2}$ miles in breadth. It is divided into square compartments, the wide and well-paved streets crossing each other at right angles. The houses are plain structures built of red brick and marble, and there are five squares laid out as parks in different parts of the city. It is abundantly supplied with water, drawn from the Schuylkill by powerful and ingenious water-wheels, and collected in extensive dams and reservoirs erected at Fairmount, a picturesque eminence in the vicinity. The water-works cost 432,512 dollars. Philadelphia is remarkably clean and neat, but owing to the unbroken uniformity of its streets, it has a rather monotonous appearance. Most of the thoroughfares are planted with trees, and the steps of the outer stairs of a vast majority of the houses are constructed of white marble, and the tops of their outer railings are of brass. The contrast thus secured is very pleasing. A large proportion of the public buildings of Philadelphia, which compare favourably with those of any other city in the Union, are either wholly constructed or faced with the beautiful white marble, which is found in abundance in the marble quarries of the neighbouring counties of Montgomery and Chester. Among the edifices most remarkable for their architectural beauty are the Custom House, originally built for the United States Bank, a fine Grecian structure on the model of the Parthenon at Athens; the Pennsylvania Bank, a marble building which has on each front a portico with six Ionic columns; the Girard Bank, an edifice cased in marble and adorned with a Corinthian portico; Girard College, a noble pile entirely surrounded with a colonnade of Corinthian columns; the Merchants' Exchange; the Mint of the United States; the Post Office; and the Masonic Hall. The State House, where the Declaration of Independence was framed and signed, is the building most noted for its historical association. Independence Hall has been carefully preserved in the state it was in when the founders of the American Republic held their deliberations in it, and it contains a statue of Washington which, though executed in wood, is considered a striking likeness of "the father of his country." There is an extraordinary number of churches in Philadelphia, estimated at some 350, including about 60 Episcopalian, 71 Presbyterian, 30 Roman Catholic churches, and two synagogues. The United States Arsenal is an extensive establishment, and from the navy yard some of the largest men-of-war belonging to the Republic have been launched. In the north-west quarter of the city stands the State Penitentiary and County prison, a massive granite building in the castellated Gothic style, planned on what is called the panopticon principle, comprising upwards of 400 cells, radiating from an octagonal tower in the centre, where the sentinel has all the doors in view at once.

Philadelphia is noted for the number, extent, and excellence of its educational, literary, and benevolent institutions. It contains 4 colleges, 2 high schools, 54 grammar schools, and considerably more than 250 schools of lower grades, with edifices owned by the city. We shall give a special notice of some of the most important of these in our next paper, and show briefly the present state of the home and foreign trade and commerce of Philadelphia.

THE LATHE.—V.

By Henry Northcott.

SLIDE-RESTS: THEIR USES AND ADVANTAGES.

It is seen that by double gearing and the employment of steam-power, any speed and any required force can be obtained, whilst the lathe rotates quite independent of any exertion on the part of the workman, although perfectly under his control. The turner's work consists consequently solely in applying and guiding the cutting tool, and to this he is enabled to devote the whole of his attention and energy. The labour for light or ordinary moderate heavy turning is neither fatiguing nor difficult; but when articles of large diameter have to be turned, considerable force has to be exerted simply to hold the tools against their cuts, and prevent them removing material where none is required to be removed. It is also quite impossible to keep the muscles perfectly still, and absolutely under control, so the tools are very apt to be unsteady also, and to produce untrue work. It is much more difficult to keep the tool quite still against a cut than to keep it moving in any required direction. It is an easier matter to turn an article of curved or irregular outline by hand tools than to produce a regular cylinder perfectly parallel or a perfectly plane surface by the same means, and the difficulty increases with the size of the article. When work of the latter kind became often required it was found necessary to substitute for the human hand some more rigid if less accommodating appliance for holding the tools against their cuts; and the instrument termed the "slide-rest," as now constructed, perfectly supplements the uncertainty of the unassisted hand, and for such work as in performing which the hand is most uncertain and unreliable the action of the slide-rest is very complete and efficient.

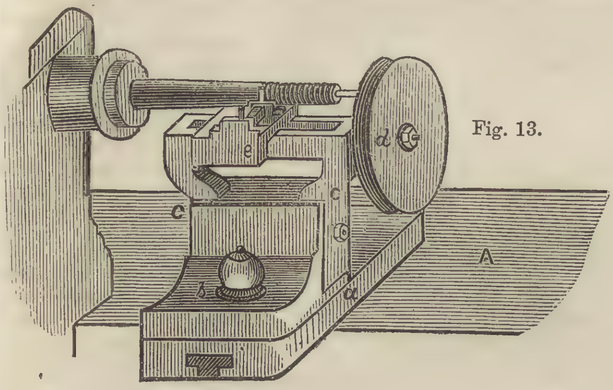


Fig. 13.

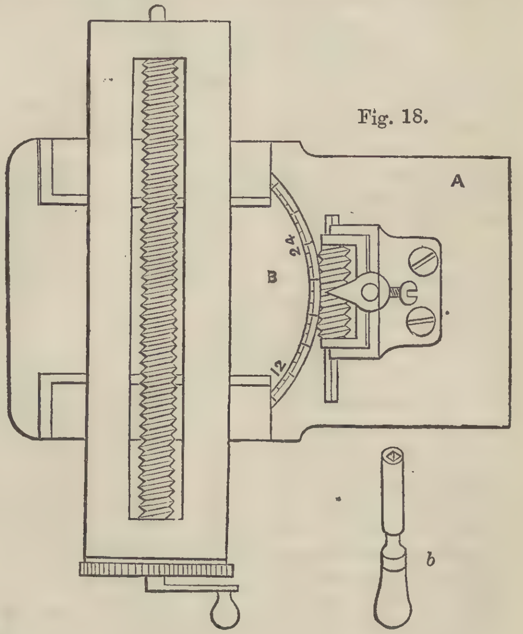


Fig. 18.

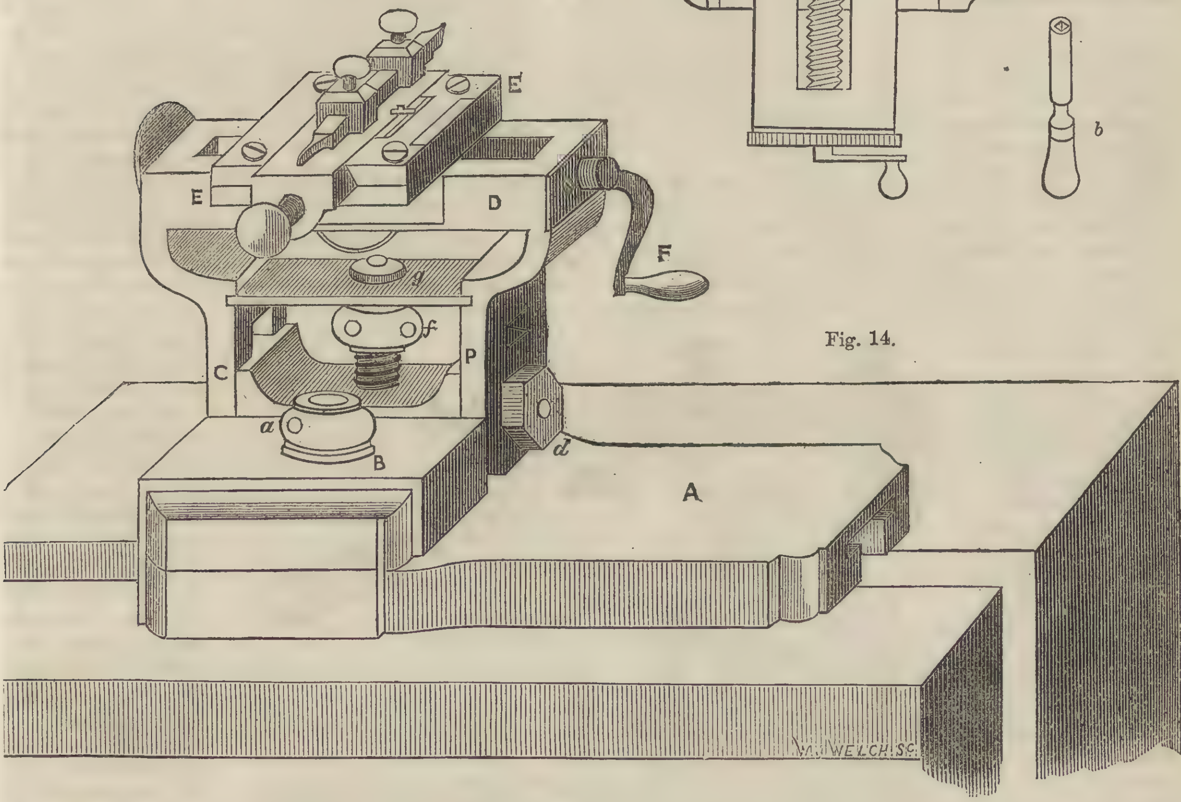


Fig. 14.

Suppose a piece of work in the lathe, and a tool held in some rigid holder in such a position that its cutting edge acted upon the work, then as the work rotates the tool will obviously cut away the projecting material and leave a plain ring or turned

circle, as every part of the turned circumference will be equidistant from the axis. When the tool is held in the hand, if the diameter of the work be small, the tool may be still considered as held in a rigid holder whilst the work makes a single turn, and the figure produced upon the work a true circle, as small articles rotate too rapidly to be practically affected by any slight muscular movement. But when the article has a large diameter it requires to be rotated much slower, and a slight movement of the tool, causing the cutting point to go deeper or less deep into the material, results in the production of untrue or unsymmetrical work, as the figure produced by the moving tool upon the moving work is no longer a perfect circle, some parts of the outline being farther from the axis than others. This is obviated by using a rigid holder for the cutting tool, and if we imagine that this holder, and consequently the tool, is moved along the work a short distance after each rotation of it, we can conceive the principle of the slide-rest. If in making these changes of position care were taken to keep the cutting edge at the same distance from the centre line of the rotating work, a parallel cylinder would be produced. The main functions of the slide-rest are to hold the tool firmly to its cut during the rotation of the work, and to allow of the cutting edge being advanced after each cut in a given right line.

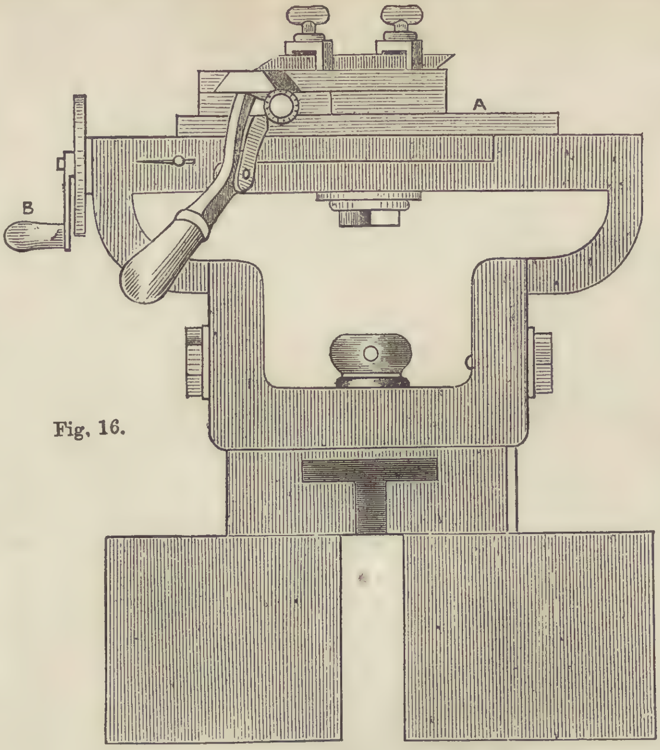


Fig. 16.

Although double gearing has been described first, so far as I can see the slide-rest was invented before it; and in Bergeron's excellent work (to which, and to Plumier's, as already mentioned, I am indebted for much information on the early forms of lathes, and early lathe work) there are several complete illustrations of this extremely useful instrument, which I here reproduce. Bergeron, in describing the slide-rest shown at Fig. 14, says, that seeing that these rests are particularly intended to turn square and oval work, that in turning these classes of work the lathe is considerably strained and shaken, and that this shaking is likely to affect injuriously the article that is being operated upon, it is advisable to make the rests wholly of metal, with a view of giving greater steadiness and stability to them, and lessening the vibration of the tools they carry.

The foot or hand plate, *a*, of the slide-rest described at Fig. 13 is much the same as the foot of an ordinary hand-tool rest, and is described as being made of brass. The bottom surface of it is brought to a true surface, and has a T-groove cut lengthwise in it underneath to receive the head of a bolt of corresponding shape, whose use is to fasten the foot and the mechanism it carries firmly down upon the lathe-bed, and which bolt-head is enabled to slide throughout the length of the T-groove, so that the rest may be fastened down upon the lathe-bed, A, at any required distance from the surface of the work to be turned. The part *b*, also of metal, is fitted nicely to *a*, the two surfaces in contact being rendered true and level, and they are held together by means of a bolt shown in front. The sides of *b* are fitted with two grooves forming slides for the reception of the two projecting feet or male slides, *c*. This arrangement of slides has for its object the adjustment of the height of the horizontal slide forming the top part of the part *c*. When the required height is decided upon, the position of *c* is maintained by tightening the two nuts at the outside of the slides. The bolt itself passes completely through both *b* and *c*, forming as it were a part of the former, and each end is furnished with the nut alluded to, by which the two parts are fastened firmly to each other. Only the right-hand nut is visible, but its position sufficiently indicates the place of the other. The upper ends of the two legs or slides of *c* are joined together by a bridge-piece formed of the same piece of metal, and this bridge serves as a horizontal slide for the small movable carriage upon which the cutting tool is mounted. The bridge-slide has a long slot through its length, and from its top surface to underneath the bridge. A small screw, *d*, passes from end to end of the bridge-slide, through the middle of the slot, and has its

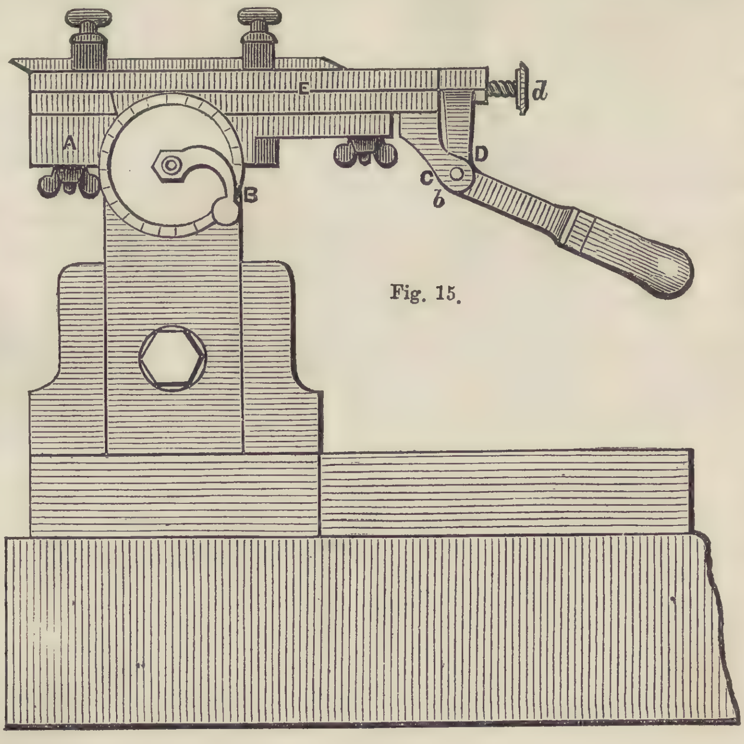


Fig. 15.

bearings in the metal of c at each end. Only the extreme end of the screw d is visible, as the chief part of it is hidden in the slot; the end visible is seen furnished with a pulley, but a small winch-handle would be used in preference to the pulley for moving the screw round by hand. The tool-carrier, e, is nicely made to slide evenly along the bridge-slide, and this movement is caused by the screw d, as a small projection forming part of e comes down into the slot, and there forms a nut for the traverse-screw. The configuration of the tool-holder and the position of the tool are sufficiently obvious from the sketch. This simple little apparatus contains everything necessary to render it an efficient sliding-rest or mechanical hand, and no doubt its use was found extremely advantageous in the production of light turned work formed of straight lines. It has provision for arranging its distance from the lathe-centres according to the size of work it was called upon to turn; it has provision for placing the carrying-slide at an angle so that the tool may be moved along in the direction rendered necessary by the required outline of the work; and it has provision for adjusting the height of the slide according to the thickness of the tool and the nature of the material to be operated upon. The tool-holder, also, is of very convenient form, allowing the tool to be quickly placed in position and easily removed for grinding or substitution. Altogether, this little slide-rest must be considered a very creditable production, and an important, because useful, invention.

In Fig. 14 is shown a slide-rest of similar construction to the last, but more complete, and embodying some features of improvement. The foot, A, is of metal, planed underneath, and furnished with a T-groove for the head of the fastening-down bolt; B is formed also of metal very much in the same manner as the last; it is fastened down upon A by the screw a. The legs, P C, of the horizontal slide have forks cut in them, and are fitted upon two tongues of metal, being projections from B. This mode of fitting is to give the horizontal slide great stability, and prevent the rising slide being a source of unsteadiness. The position of the vertical slides is maintained by the screw d in the same manner as in Fig. 13, but the adjustment to the height required is made by means of the capstan-headed screw f, which screws into the metal of B below and rotates freely in the plate g above. The bridge-slide D has a slot through it, and carries the tool-slide E in much the same way as in the last example, the V-pulley on the screw being, however, here replaced by a winch-handle, F. The tool-slide, E, is much more complete than in Fig. 13, as it is provided with an additional slide at right angles to the slide D, and to this additional slide the tool is attached. Provision is also made in these slides for setting the cheeks of the slides closer together as they wear slack, and so prevent any shaking or unsteadiness of the tool, which would otherwise result from the wear of solid slides. The use of the additional slide is to regulate the penetration of the tool and the depth of its cut: the manner in which it subserves this purpose is readily seen from the engraving.

Another still more complete form of the slide-rest is shown in side and front elevation by Figs. 15 and 16, and in plan at Fig. 17. This slide-rest has two points of difference from the last we have described, and both points are embodied in the most modern slide-rests without any material modification. By referring to the illustrations it will be seen that the lower portion of the slide-rest is almost exactly the same as those already described, but the small carriage A of the horizontal slide D is continued outwards to form a broad flat plate with a long circular slot or groove cut through it. The edge of this circular slot is divided into degrees for convenience of adjustment. The carriage is moved along the slide by the usual screw, in the end of which is a handle B, and a circular plate divided on its edge as an index whereby the traverse of the slide could be seen and regulated. The top part of the carriage and flat plate is very nicely filed up to a true surface, and the bottom surface of a second plate E is similarly prepared and fitted down upon A. In front at a (Fig. 17) a small bolt passes down from E, and goes through A with a thumb-screw beyond; this bolt acts as a fulcrum or centre, around which the part E may slide upon A. At the back end of E another small bolt similar to the last passes down through the circular slot of the plate A, and has a thumb-nut beyond for tightening it up. The object of this arrangement is that the part E which carries the tool may be moved round upon A, and the point of the tool by this means caused to describe a circular arc. The radius would obviously depend upon the position of the tool's point in relation to the centre or fulcrum around which it was moved, and the length would be regulated by the divisions marked on the edge of the circular slot.

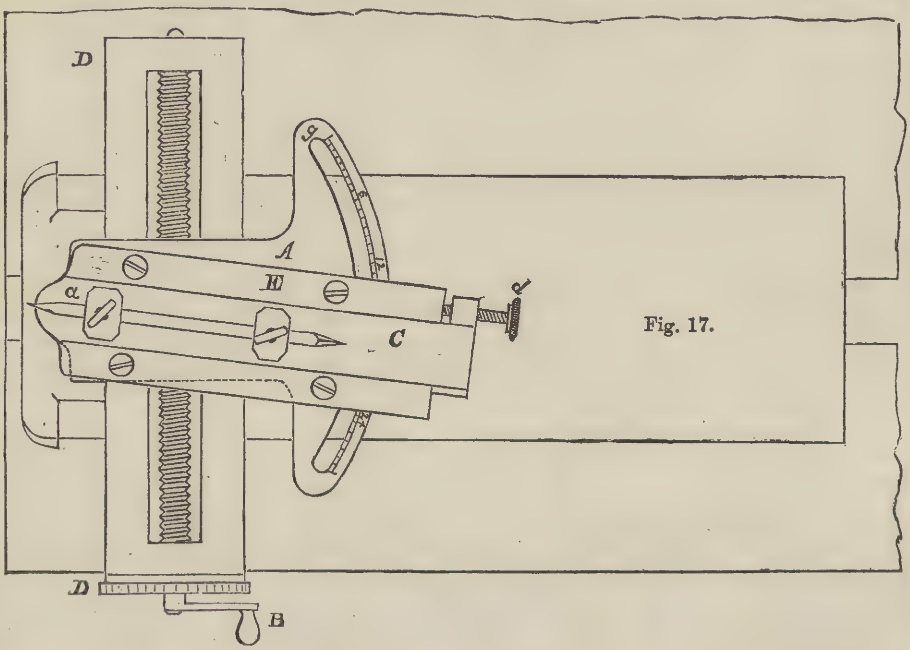


Fig. 17.

The tool is carried by a separate slide as before, and the tool is held in place by two finger-screws, which enable it to be easily removed. Instead, however, of the tool being moved into and out of cut by a traverse-screw, a lever D was employed for this purpose, which enables the movements to be produced with greater readiness and rapidity. This lever was carried by a lug, C, projecting from the slide E, and affording a fulcrum for the lever at b; one end was in contact with the tool-slide, and the other end furnished with a handle, as shown in Figs. 15 and 16. A small screw, d, at the side, best seen in Figs. 15 and 17, was employed to supplement the handle, and regulate and determine the depth to which the tool should cut.

This application of a lever for running the tool in and out is a great convenience for light ornamental turning, but it is not applicable to lathes intended for heavy turning or metal work. The circular motion of the tool-slide as here worked out was not of great value. The rest was intended for the production of spherical curves, but it was not well adapted to produce them, nor did the circular movement give any greater facility for the production of cones and angles; but in the next arrangement, as shown at Fig. 18, the position of the circular slide was altered and placed, as the reader will notice, below the main horizontal slide instead of above it.

In this slide-rest, the top surface of the foot or base-plate A was made smooth so as to form a part of the circular slide, the other part being formed by the plate B. This plate was fastened to A by a central bolt, which permitted it to turn freely round, and the outside edge of the plate B was cut with screw-teeth to form a segment of a worm-wheel, into which the tangent-screw or endless worm, *a*, geared. The tangent-screw was of course fastened down upon A. Upon the plate B was mounted the main slide, which latter was of the same form, and carried the same kind of tool-slide as in Fig. 15. The main slide only is represented in the engraving, to make the arrangement as little complicated as possible. In this slide-rest the circular movement of the top slide is brought about by moving round the tangent-screw *a*, a handle *b*, as shown in our illustration, being provided for the purpose.

The application of the tangent-screw was in itself an improvement, as the circular motion was thereby obtained in a manner much more equable and more under control. But by placing the long slide upon the circular slide, instead of the reverse, a much more convenient means was afforded of placing the slide at an angle to the line of the lathe-centres, when conical or angular work had to be turned. The slide-rest was, even with the successive improvements we have already noted, still not well adapted to act as a spherical rest; but with the tool-slide shown at Fig. 15, and the circular movement of Fig. 18, it had become a very useful adjunct to the lathe.

CHEMISTRY OF THE FINE ARTS.—IV.

By Professor CHURCH, Royal Agricultural College, Cirencester.

GUM, GLYCERINE, HONEY, AND GLUE—LIME—WATER-GLASS: ITS PREPARATION AND PROPERTIES.

THERE still remain for consideration a few materials of organic origin, which are employed in certain processes of painting. Of these organic products some of the gums are of importance, especially in connection with the use of water-colours. *Gum arabic*, a natural exudation from several species of *acacia*, is a much more highly oxygenated substance than any of the materials studied in our last lesson. Its specific gravity, when white and pure, is 1·36, and it is completely soluble in cold water, but insoluble in spirit. It contains a slightly acid substance, called arabic acid, united with lime, potash, and magnesia; its per-centage composition is—

Arabic acid	71
Water	18
Lime and salts	11
	100

Gum arabic may be partially purified from salts by boiling its powder in alcohol, which is then to be poured off. Or it may be completely freed from extraneous matters by the addition of acetic acid to its solution, and the subsequent dialysis of the mixture, pure gum remaining on the dialyser at the end of a few days. *Gum Senegal* closely resembles gum arabic, but is somewhat more tenacious, and is nearly free from saline matters. Its specific gravity is 1·44. These two gums serve, when in solution, as media for water-colours, solid coloured particles remaining long suspended in them, and being also thus bound together and to the paper or other painted surface. The gums also exert some protective influence on the pigments with which they are mixed, and thus correspond to the resinous and other vehicles of oil-painting. Gums, however, afford no security against water or even damp; while some of them, if freely used in painting, actually encourage moulds. A solution of gum arabic may be kept sweet, and free from acidity or fungi, by means of a lump of camphor kept floating in the bottle, or by the addition of less than 1 per cent. of pure carbolic acid. Dextrine, British gum or mucilage, a substance derived from starch, must be carefully avoided in all artistic work; it is specially prone to change.

Many years ago the writer of these lessons tried some experiments on *glycerine* as an addition to gum-water or to isinglass solution in the preparation of moist colours; used sparingly it proved very useful in preventing some coloured layers from cracking, and also in preserving the pans of coloured substances in a working state. The best distilled glycerine must be employed, and as it attracts moisture from the air, it can only be introduced into pigments in very minute proportions. The liquid part of honey which has been kept some months, or the sugar extracted from honey by cold alcohol, may be substituted for glycerine. In preparing this sugar by the alcohol method, the spirit must be distilled off in a retort; the remaining syrup is known as fruit sugar or fructose.

The presence of the element nitrogen to the extent of 17 per cent. in glue, isinglass, gelatine, and size, renders these substances very distinct, in a chemical point of view, from those which we have just studied. They are liable, under many conditions, to change; and as they contain nearly 1 per cent. of sulphur, this change is sometimes attended by the separation of sulphur compounds injurious to lead-pigments. From whatever materials the "size," or solution of these nitrogenous matters, be prepared, its purity is of great importance. Russian isinglass, prepared from the lining membrane of the swimming bladder of the sturgeon, affords one of the best kinds of size when dissolved in boiling water and strained through muslin. Ivory dust, vellum and parchment-clippings, fish-bones, and several other similar materials, yield a clear and colourless size by sufficiently prolonged boiling in water. Whatever crude substance be taken, it should be thoroughly washed in pure water, soaked in lime water, and again washed before being converted into size. If white of egg or the albumen of blood be employed, it should be purified by dialysis, as already described under the head of gum.

We must now turn our attention to one of the most important art-materials which we have yet mentioned—*lime*. This substance forms the basis of all the grounds used in distemper and fresco painting, and is employed in two states, as carbonate of lime and as hydrate of lime, compounds which in modern chemical language are termed respectively "calcium carbonate" and "calcium hydrate." When chalk, marble, or limestone is strongly heated or "burnt," it loses the carbon dioxide or fixed air which it contained, in accordance with the equation—

$$CaCO_3 = CaO + CO_2.$$

The CaO remaining is burnt lime, quicklime, or caustic lime. Perfectly pure limestone should yield 56 per cent. of quicklime. When quicklime is placed in water or wetted it absorbs water, becoming slaked, but still retaining its caustic or alkaline character—

$$CaO + H_2O = CaH_2O_2.$$

100 parts of pure burnt lime absorb 33 parts of water. Now, when slaked lime, which is a white dry powder, is exposed to the air, it slowly absorbs carbon dioxide (CO_2), becoming at last re-converted into the original carbonate from which it was made—

$$CaH_2O_2 + CO_2 = CaCO_3 + H_2O.$$

With reference to lime compounds for artistic uses, two questions are suggested. From what native materials should they be prepared? and in what condition should the products be employed? It does not appear that the native lime compound taken need be very pure. It may contain bitumen, as in black marble; or magnesia, as in dolomite; or traces of silica, alumina, or iron, and yet yield a good lime. Still, the nearer the product approaches to pure lime, or to a mixture of pure lime and magnesia, the less probability is there of any drawback arising from its use. The next point is the slaking and preparing the lime. This is accomplished by mixing it with water and introducing it into a grouting box, the sluice of which is an inch or two from the bottom. When the slaked lime is reduced to the consistence of a cream, the sluice is opened, and the semi-fluid mixture allowed to flow out. With this mixture a covered pit dug in the earth, or made of brick or stonework, or better still a tank of slate, is filled. Here the white paste remains, covered loosely, for two months, when it is ready for all the rougher processes connected with fresco and distemper painting. For finer purposes and for use as a pigment or admixture with pigments, the lime must be again submitted to the grouting operation, strained through hair sieves, and run into earthenware jars. Here the water which collects at the surface is now and then poured off, while the white paste below will be found soft and easy to work, free from grit and salts, and to have lost some of its causticity, having become slightly carbonated. As long as it is kept in a closed jar it cannot become less caustic, nor is it desirable that this change should proceed to any great extent, or the binding and hardening properties of the material would vanish; not

more than one-third of the lime should become carbonated previous to use. If it be dried and then again moistened, or if it be mixed with carbonated water (soda-water) and then allowed to settle, carbonation may be accelerated. On the other hand, as lime-paste apart from the air suffers no injury, it may be kept in cellars, in closed jars, for years, with the certainty that it cannot then produce any of those blisters or other defects in fresco paintings which irregularly slaked lime is known to cause. A large quantity of such old lime-paste, of excellent quality, is stored in the cellars of the Houses of Parliament; the present writer has made many experiments with it, proving that the bad condition of the frescoes painted with this material is due, not to any defect in it, but to such entirely different causes as the injurious action of coal-gas, a London atmosphere, etc. etc., and possibly in part to the inexperience of the artists in the peculiar method of painting required. There can, however, be no question that while slaked lime may be long kept and still preserved in good condition, a shorter period after slaking is sufficient to allow of that complete hydration of the quicklime, which prevents blisters being formed on the surface painted with it. Great confusion exists in the minds of fresco writers on this point, for while they rightly recognise different degrees of causticity in different limes, they rarely attribute these variations to the true cause, namely, the absorption from the air of carbonic acid gas, the gas that is now generally called carbon dioxide. It is, however, absolutely necessary that this combination should not have completely destroyed the caustic property of the lime. If it has proceeded very far, the lime has scarcely more binding power than common chalk or whiting, and will serve neither to make a firm ground for the picture nor to cement the colours to the surface. When two-fifths of the lime are carbonated—easily ascertained by a rapid analysis—it is in an excellent condition for fresco grounds, though it may be used in a still less caustic state for mixing with pigments. In speaking in the next lesson of the actual processes of painting, we shall have occasion to recur to the subject of lime.

Of the materials employed in silicious painting it will now be necessary to say something. We begin with a brief account of *water-glass.*

Water-glass, however it may vary in the exact proportion, and even nature of its constituents, is essentially a soluble alkaline silicate. Four varieties of it have been used in silicious painting, the first containing potash and silica, the second soda and silica, the third being a mixture of the first two, and the fourth being one of the former kinds rendered more strongly alkaline. These varieties of water-glass may be prepared by two distinct processes. In one of these, flints or other silicious materials are heated in closed iron vessels with soda or potash lye; in the other process the silicious substance is fused with an alkaline carbonate. The latter method is more easily managed under ordinary circumstances, and gives a very satisfactory and pure product. In adopting the other process, it is advisable to heat the flints, etc., red-hot, and to quench (*étonner*) them in cold water before introducing them into the vessels in which they are to be heated with the caustic alkaline liquor, under a pressure somewhat greater than that of the atmosphere. By fusing quenched and powdered quartz or washed silver sand, 15 parts, with 10 parts of purified potash, and a little charcoal, either in a graphite crucible or on the hearth of a reverberatory furnace, a clear glass will be obtained after some five or six hours. This is to be poured out on a slab, broken up, and boiled with pure water till it has almost completely dissolved. By subsequent evaporation of the solution (strained, if necessary, through a little asbestos or pumice, but not through paper), a liquor is obtained which contains silicate of potash or potassium silicate in solution, and which has a specific gravity of about 1·25. A soda water-glass is obtainable by a precisely similar series of operations, adopting, however, the following proportions: 45 parts of quartz, 23 pure dry carbonate of soda, and 3 of powdered charcoal. A mixed water-glass is furnished by the fusion of the following mixture: 50 parts quartz, 14 parts dry carbonate of potash, 11 parts dry carbonate of soda, and 3 parts of charcoal. These materials are much more easily and rapidly fused than those previously named. The solution which the product from them yields is probably the best material that can be employed in stereochromic or silicious painting. If, however, it should be saturated with silica, which may be the case, it is advisable to employ it only after it has been rendered more alkaline by the addition of a little caustic potash. The quantity to be added may be ascertained in the following way:—We shall find our water-glass solution somewhat opalescent; to it we add a 10 per cent. solution of caustic potash, with constant stirring, until the opalescence has disappeared. The quantity used for this purpose being noted, a further addition is made of one-quarter the amount.

An impure solution of water-glass may be rendered better fitted for stereochromic work by precipitation with from one-fourth to one-third its bulk of methylated spirits of wine, and collecting, pressing, washing slightly, and finally re-dissolving the gelatinous precipitate thus obtained. Chlorides, sulphates, sulphides, and sulphites are objectionable impurities in a water-glass. It is a mistake to have the water-glass solution neutral. If not distinctly and even strongly alkaline, a white silicious bloom will form on the painting executed with it. On the other hand, a great excess of alkali is objectionable, for it may favour the production of a saline efflorescence, and prevent the colours from drying and hardening properly, and exert a prejudicial influence on some pigments which might otherwise be safely employed.

The composition of *neutral* water-glass is represented by the chemical expressions—

Potash water-glass	$K_2O,4SiO_2$;
Soda water-glass	$Na_2O,4SiO_2$;
Double water-glass	$KNaO,4SiO_2$.

It might be supposed that these silicates of the alkalies would suffer double decomposition with the limestones and calcium carbonates with which they come in contact. This seems scarcely to be the case; but they form double compounds with them instead. So there is but little sodium carbonate formed when sodium silicate and calcium carbonate are mixed together and kept some time. The reactions of water-glass with some other substances are, however, more pronounced. Zinc white is largely used in preparing grounds for stereochromy, and it is found to form a silicate of zinc and the alkaline metal, liberating a little alkali in so doing, however. Burnt or calcined magnesia sets still more readily with water-glass than zinc white: lime and its phosphate may also be employed in the preparation of water-glass cements and grounds.

GREAT MANUFACTURES OF LITTLE THINGS.—V.

BY CHARLES HIBBS.

PINS (*continued*).

THE difficulty of keeping a pin's head properly on its shoulders led to many attempts to produce the now universally-known solid-headed pin. The first patent for the purpose of which we have any record in England was taken out by Timothy Harris, of Waltham Abbey, in the year 1797. His method was to *cast* the heads upon the shafts, employing for the purpose a mixture of lead and antimony. Two years previously to this, however, a patent had been taken out in France for making pins, the head and shaft of which should be of one piece, but of this we have no detailed description. But neither of these patents seem to have revolutionised the trade, for twelve years later we find a patent by William Bundy, of Camden Town, for an improvement in the method of fixing the old-fashioned wire heads. He simply proposed to rivet them on a dozen or two at a time, instead of singly. The pins were placed in a pair of grooved dies, which were then screwed tightly together. The heads were placed on by the fingers, and a third die, under a fly-press, fastened them all at one blow. This method was soon abandoned, being, if anything, more tedious than the original one. In 1812 the firm of Bradbury and Weaver, of Gloucester, made an automatic machine for placing the heads on the pins, conveying them to be rivetted, and afterwards removing them. This machine made a flat-shaped head, with a good finish, but did not conquer its incurable defect of slipping down the shaft. Five years later we see the first introduction upon the patent records of a plan for making the head out of the substance of the shaft. Seth Hunt, in 1817, claims the merit of making pins, "with head, shaft, and *point*, in one entire piece." The wire was fed up to a machine, and seized by a die; a pin's length was then cut off,

and the die held it while the head was formed by compression; the same die still held it while the point was formed, which was accomplished by the die turning round four times each way, while a cutting wheel rose in a proper position to catch the point. This must have been an ingenious machine, but it did not succeed in making good a footing in the trade. The heads formed by compression were probably not very workmanlike in their appearance. In 1824 the first real practical step in this direction (as it afterwards turned out) was taken by Mr. Lemuel Wright. His machine, although not in itself a success, gave the cue to improvements which resulted ultimately in the machine we now have. Nevertheless, Wright's machine differed from those now in use in all but the main principles. The pins were made directly from wire carried on a reel to the machine, and drawn through straightening pegs. A pair of cutting nippers then severed the length of a single pin; a carrier took this to a bevelled roughened wheel, against which it was held and rotated; another carrier took it to a second wheel of finer cut, which finished the point; another carrier took the pin to a heading die, when the head was roughly formed by the pushing up of a punch; and a fourth carrier took it to another die, which finished the head, and the pin was complete.

Though it struggled on with great difficulty for many years, Wright's machine was destined, as we have hinted, to lay the foundation of the future trade. Many successive improvements to it were tried and discarded; many speculators took it up and abandoned it; many handsome fortunes were sunk in it; but at last, in 1833, nine years from the date of the patent, the first solid-headed pins were thrown upon the market, and have kept it ever since.

Leaving it for a moment, let us examine a few of the ingeniously complicated contrivances that were patented for the same object, while Wright's machine was in its nonage. In 1831 Daniel Ledsam and William Jones took out letters patent for a machine, which, after forming the heads of the pins by pressure, pointed them by a process which is thus described:—"To point the pins, they are fed from a hopper on to the periphery of a wheel, which is grooved to take the heads. The pins then lie parallel to the axis of the wheel, and pass between the wheel and a fixed curved lever, held by a spring against the periphery of the wheel. Both the periphery of the wheel and the surface of the curved lever are covered with washed leather, and thus a rotary motion is communicated to the pins. While moving thus, their points come in contact with a rapidly rotating file, which sharpens them."

In 1835 Samuel Slocum patented a machine, which is described as follows:—"By means of inducting rollers moved by a ratchet wheel, a length of wire sufficient for a pin is introduced, and enters what is called a 'spring chuck,' a number of which are situated round the periphery of a wheel. The chuck holds the blank, which is now cut off from the main wire. The heading frame advances, and the dies close firmly round that portion of the wire which projects beyond the chuck, while at the same time the heading punch strikes up a head between the dies. The head being thus formed, the wheel revolves till the next chuck comes into position to take a blank. The same movement, however, carries the first chuck opposite a stationary cutter, which trims up the revolving head of the pin, already shaped in the dies. The next movement brings the head opposite a small punch, which forces the head up to the chuck, and consequently drives the point out at the other side to be ready for the pointer, which it reaches at the next stage. It then passes successively to other cutters, which finish up the point; and, finally, it comes to rest opposite a 'hooking piece,' which draws it out of the chuck, and allows it to fall in some convenient receptacle."

The reader will, doubtless, think that these two machines would form very pretty mechanical toys for an exhibition. Of the same character is the following, patented in 1841:—

The pin-shafts, pointed and cut, are placed in a hopper, whence they pass, one by one, into a groove on a metal plate. A plunger pushes the pin into the jaws of a holder, which then travels laterally, till it comes opposite the heading dies. "The pin-shaft is taken between these dies, and left there by the holder, which returns for another shaft. This return movement of the holder brings a second holder to the shaft now in the dies. This holder takes the shaft, while the heading plunger upsets the head. Thence it carries the half-headed shaft, released from the dies, to a second heading plunger, which completes the pin."

Let us now return to Wright's machine. Though pins with solid heads were produced by it, as we have said, in 1833, such were the difficulties connected with its complete working, that for many years the pointing continued to be done by hand. The machine was further perfected by D. F. Taylor and Co., of Stroud, who carried on the manufacture by its use with very feeble success, and after four successive companies had taken it in hand, and made nothing of it, the whole plant was purchased by Messrs. Edelsten, Williams, and Co., now of Birmingham, about 1843. From that date the days of pin-making by hand were numbered. The new firm were thoroughly practical men, and in four or five years had durably established the trade upon a new basis.

It would take too long to describe the many modifications of Wright's original patent, which have made the present machine what it is: we must be content with endeavouring to convey some notion of its very ingenious construction. It seems to give one the idea of a very *handy man;* one whose deft fingers can perform two or three operations at once, without the waste of a tittle of time or energy. It could be put into a good-sized portmanteau, but it has as many contrivances packed into its small compass as a modern dressing-case. The wire, as we have said, is drawn into the machine direct from the coil, passing through straightening pegs. A pair of heavy iron fingers close upon it when it has reached a certain distance, and hold it while three quick, chopping blows are administered upon its head; "dubbing" it up into perfect and comely shape. A cutting instrument then comes into play, and cuts off the pin, just as the iron fingers unclose, and let it drop into an iron trough lying down the side of the machine at an angle of 45°, or thereabouts. The bottom of this trough is not closed, but is one long slot, just wide enough to let through the shaft of the pin, but not the head. The pins, therefore, soon find their way to an upright position, and travel down the incline, hanging by their heads, simply by their own gravity and the shaking of the machine. When they get to the bottom they turn a corner in regular order, the trough being continued, and follow each other in single file along the front of the machine, where the pointing wheels are revolving. As they pass along the slower gradient of this part of the trough, assisted by the vibration, and by the pressure of those behind, they come successively in contact with coarse and smooth rotary files, and become beautifully sharpened by the time they reach the end, and drop off into a pan.

The seemingly almost intelligent motions of this machine are directed by cams, which come into play at the proper moment by one revolution of the spindle. Our readers know what a cam is: it is simply a wheel with a lump upon it. Let us inspect, by way of example, the mechanism of that quick little iron fist which delivers its blows with such precision and effect. Its striking end is, of course, cut to the converse shape of the top of the pin-head; its arm, or shaft, slides easily between "journeys," and its other extremity is furnished with a roller. A spring underneath keeps this roller pressing on the periphery of a wheel fixed on the spindle. This wheel has three lumps upon it; and, as it revolves, it shoots forward the striking punch three times. In like manner, the iron fingers that hold the pin are normally kept open by the pull of a spring, but other wheels on the same spindle, which have lumps on the side instead of on the circumference, press against levers in the course of their revolution, and close up the fingers with a grip like that of a vice.

The sticking machine, which is of American invention, is of not less ingenious construction. As it does not come within the subject of pin-making proper, we have no need to describe it; but the neatness and celerity of its movements, and the accuracy with which it performs its work, would be very attractive to a spectator. Pins have an inveterate habit of lying sixes and sevens when in a heap, and this machine turns them about, reduces them to order, and marshals them in a row, with all the precision of a drill-sergeant, in a manner that is both simple and amusing. It is much more agreeable to watch these machines than those we have described, on account of the deafening rattle of the latter. Where twenty or thirty of them are at work in a single room, the "music of the mill" is of a distressingly ear-splitting character.

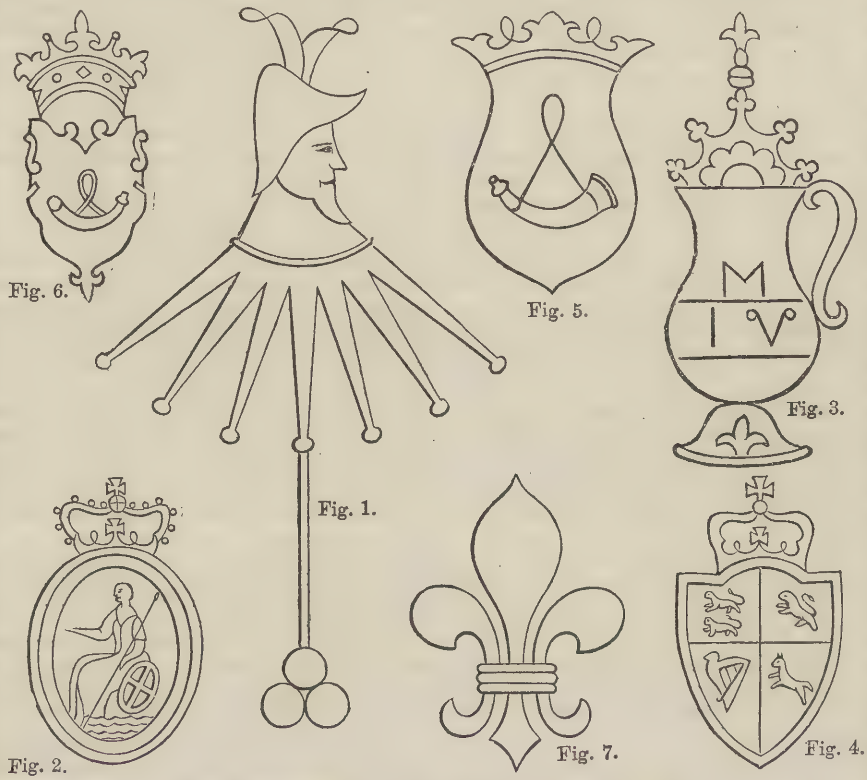
PAPER AND CARDBOARD MAKING.—V.

BY GEORGE TINDALL.

PAPER-MAKING BY HAND, AND FINISHING.

The making of paper by hand is analogous to the process by machine, but instead of a continuous web of paper, each sheet is made by a separate operation, and the size of the sheet is limited by the power of the operator to handle the mould or framework in which it is made.

The process of preparing the pulp is precisely the same as for machine-made papers, and the pulp when ready is run into a large chest or vat and mixed with a sufficient quantity of water. The workman then, standing by the vat, takes the mould—which in this case acts both as the machine-wire and as the dandy-roll, and consists of a framework of the size required, of wire gauze if for a wove paper, and made like a laid dandy-roll but flat if for a laid paper, and having a loose frame or deckle around it, projecting slightly above the wire for regulating the thickness] of the sheet—and dipping it into the vat he withdraws it full of the pulp. He then gives to it a gentle undulatory motion, causing the pulp to form in an even, regular sheet as the water passes away through the mould, and hands it to the assistant, taking off the loose frame, which he places on another mould and repeats the operation, while the coucher turns the former sheet as it lies on the mould on to a piece of felt conveniently placed, and covers it with another piece of damp felt ready for the next sheet. This operation is continued until a sufficiently large pile of sheets and felts, placed alternately, is prepared, when these are taken to a press and subjected to considerable pressure to force out the water and compact the fibres together. When sufficiently pressed, the pile is taken out and the sheets are taken from the felts and placed in a heap one upon the other, and these are then taken back to the press and subjected to very considerable pressure a second time.



WATERMARKS USED IN THE MANUFACTURE OF PAPER.

Fig. 1.—Old Foolscap Mark. Fig. 2.—Modern Foolscap Mark. Fig. 3.—Old Pott Mark. Fig. 4.—Modern Pott Mark. Fig. 5.—Old Post Mark. Fig. 6.—Modern Post Mark. Fig. 7.—Mark for large-sized Papers.

The next operation is that of sizing, and for hand-made papers animal size is always used. The size is prepared and put into a vat, and the sheets are passed through one by one. The superfluous size is allowed to run off, and after a third pressing to secure the regular distribution of the size, the sheets are hung up on wooden laths or strings in a loft, the sides of which are formed of louvred windows, admitting a free current of air to the sheets. By this slow method of drying, the sheets contract very considerably, and the fibres become much more firmly matted together, and a much stronger paper is the result. Papers made by machine may also be sized in this way after they are cut, or the sizing may be effected by suitable machinery carrying the sheets through the size, and then they may be dried in the air in the same way, when excellent strong papers, rivalling hand-made papers, are the result; indeed, the process of paper-making by hand is threatened with extinction, so closely do some machine-made papers, sized in this way, approach them in the properties of strength and toughness.

Papers dried in this manner are very rough, and require surface and finish. This is obtained by placing them between heated copper or zinc plates, and passing a pile of these several times through a pair of rollers with a considerable amount of pressure. Most machine-made writing-papers are also subjected to this process, called plate-glazing, the finish given by the calendering apparatus in the machine not being sufficient for fine papers. A very beautiful finish can be given to papers in this way by passing them through the rollers a considerable number of times, each operation improving the surface, until the sheets may be made to resemble polished plates of ivory.

The cutting of machine-made papers may be effected either by an apparatus at the end of the machine, cutting the single sheet of paper as it is made, or if the paper is reeled on wooden rollers, these may be carried to a detached cutting-machine, and several reels may there be cut at once. Up to a very few years ago all papers were cut in single sheets at the end of the machine, and where a high speed is not attained, this is an easy task, but as machines are run at a higher speed this has become more difficult, and combined with the application of the provisions of the Factory Act to paper-mills restricting the hours of boy labour, has caused the introduction of detached cutting-machines in most mills, as the produce of a machine during twenty-four hours can be cut by this means within ten hours. The process of cutting usually involves two operations. As the paper is made wider than is required, it is necessary first to cut it into strips of the proper width, and these again require cutting across into single sheets; but the same kind of cut will not serve for both operations. For the cross cut, a knife revolving at a certain speed cuts the sheet in two, but as the length of the sheet is continuous, so the action required for the longitudinal cut is continuous, and it is obtained by two circular discs of steel with a cutting edge working against each other, like the two blades of a pair of scissors. In the most improved form of paper-cutter the reels are attached to an iron frame-work at the back of the machine, and the sheets from each reel are passed between rollers to bring them together, and then brought between a pair of small feed rollers to the pairs of cutting discs or knives. These are fastened by screws set at proper distances on shafts extending across the machine, which, being movable, can be regulated for any width of sheet. The

paper is here cut into continuous strips of proper width, and these passing between another pair of rollers are fed on to a fixed knife extending across the whole width of the machine, and at regular intervals are cut into sheets by means of a knife fixed upon revolving wheels, the size of the sheet being determined by the speed of the revolving knife, and regulated either by means of cone pulleys or an expanding wheel.

Some thick papers, such as browns, etc., are glazed by an extra calendering apparatus in continuous rolls, instead of being plated in single sheets. When this is done, the sheets are cut as they are made at the machine into strips by means of a set of pairs of revolving discs, and these slips are reeled in the same way as the ordinary sheet. They are then taken and passed between calender-rollers, one of which, instead of being of polished metal, is of paper, fixed firmly and tightly to the roller of some considerable thickness, and turned up true and polished in a lathe. These rollers revolve at different and very high speeds, and as the sheet passes through, it attains a very fine polish, having been exposed to a certain amount of friction in the process. They are then cut into sheets at the detached cutting machine in the usual way.

The same method of cutting and reeling is employed in the making of wall-papers for staining, or long elephants, as they are technically termed. These, being required in continuous lengths for the staining process, are cut as they issue from the calenders at the end of the machine, but instead of being reeled on wooden rollers, as for the cutting machine, shells of paper or wood, of very little thickness, are used. These shells fit on to an iron bar or core, as many as are required, according to the width of the machine, and when full are taken off and at once packed. Similar rolls of paper are now required for newspapers printed on the Bullock machine, an American invention, in which the printing machine feeds itself from a continuous roll, and during the operation cuts the paper and delivers it in printed sheets of the proper size.

The paper is next carried to the "salle," as the finishing room in paper-mills is universally termed, and in this room it is sorted and packed ready for the market. The operation of sorting entirely depends upon the quality of the paper, and is performed by girls and women. A quantity of paper is taken from the heap and placed on a wooden bench, which usually runs round the room, and if coarse papers are being sorted, the end of the handful of paper is by a dexterous twist turned up, exposing a portion of each sheet; the "broken," that is, the torn sheets, are then picked out, and the paper turned round and the other end exposed, to see if any sheets are broken on that side. These being removed, the paper is then "jogged" until straight and even, put on one side, and another handful operated on in the same way. Fine papers are turned over sheet by sheet, and the finest qualities are divided into three parcels, only clean, perfect sheets being passed for good paper, those sheets which contain spots, or are otherwise imperfectly made, being likewise separated from the broken and called "retree." These are usually sold at a lower price than the good, whilst the broken is either returned to the beating engines, or sold at a considerably lower price. If the sheets are of large size, such as news, the broken is often cut down to smaller common printing sizes, and this is re-sorted, a considerable proportion of perfect sheets being found, whilst the cuttings and the broken of the smaller size may be again reduced to pulp.

The paper is then passed on to the finisher, who counts it into quires of twenty-four sheets, and folds it over into the ordinary folio sheet, a round piece of hard wood or ivory being used to press down the back of the sheet to make it lie flat. For convenience of printing, and to avoid the crease, which is often unsightly, many papers are now put up flat, being counted into reams after sorting, and at once packed up in wrappers. Most news is also required flat, a machine being used for wetting the paper, instead of the old method of dipping each quire by hand; but as the parcel would be inconveniently large, it is usual to reduce the bulk to one-third its full dimensions by folding the whole ream over one side into the middle, and the other over that without pressing down the back on either side; in this way the bale carries well, and opens quite flat for the wetting machine, and as no force has been used, the slight crease made by folding is pressed out while damp. The great majority of papers are, however, put up folded in quires of twenty-four sheets, and again in reams of twenty quires. In most writing papers an old custom prevails of making the outside quires of twenty sheets only, and these of retree or broken paper, so that the stationer in buying these papers only receives eighteen quires of good paper and two quires of inferior or even worthless paper, which are eight sheets short—a practice much to be deprecated, as a false representation of the quantity of paper sold, and one that will, we hope, soon be numbered with other bad customs of the past. Printings and wrapping papers are now very rarely retreed, but are made up in full reams of twenty perfect quires; indeed, printings are now very often put up in reams of 500, 506, and sometimes 516 sheets, the latter being called "perfect;" this is obviously advantageous, as printing orders are usually given by the thousand, and under the ordinary method a ream must be broken for every order. Retree papers are marked on the wrappers with the letter R or the sign X, and if folded in half-quires, the backs of each quire are placed alternately, whilst good papers are placed in alternate half-quires in the ream.

The kinds of paper manufactured in this country are very various, but may be divided into three classes—viz., writings, printings, and wrapping papers. Up to a very recent period writing papers were almost entirely confined to blue laid and wove, cream laid and wove, and yellow wove; of late years, however, yellow-laid machine papers have been largely made in imitation of hand-made account-book papers, which, though usually called blue laid, are by no means so deep in colour as the blue-laid machine papers, but of a similar shade to the yellow wove. Tinted or coloured writings in great variety are now largely made and used for various purposes besides correspondence, and especially for printing circulars, cheques, etc. Printing-papers are almost invariably made wove, except news, for which purpose laid papers are still often used. The variety of colours and qualities of printing papers is very great, especially since the introduction of the aniline colours, the pattern books of some makers of tissues—a very thin and fine printing—showing nearly a hundred different shades. Wrapping papers are of very various kinds and qualities, from the coarsest brown and purple papers, made from the refuse of the rag-merchant and the paper-maker, to the finer qualities of printings, which are now largely used for this purpose; the principal kinds are purple sugar papers, browns, cap papers, grey and white cartridges, and printings, in a series of qualities, sizes, and weights almost interminable; indeed, so great is the variety of these papers that they are now rarely kept by the stationer, but by a distinct class of tradesmen.

In the early days of paper-making every size and make of paper was distinguished by a separate and distinct "trade mark" in the shape of a watermark, and although this practice is not now adopted except by some makers or for special purposes, we can easily trace how the names now used for various sizes of paper have arisen from the watermarks formerly used by the makers of these papers. The common and well-known paper called foolscap, no doubt, derives its name from an old watermark representing the symbol of the court jester of ancient days, the cap and bells (Fig. 1). This, however, has long since been superseded by the well-known figure of Britannia in an oval design surmounted by a crown (Fig. 2), which is now almost universally used for foolscap papers. Another favourite design for a watermark (Fig. 3) probably gave rise to the term pott paper for a size a little smaller than foolscap, and which, though nearly an obsolete size, is still occasionally made with the watermark represented by Fig. 4. Post paper, no doubt, derives its name from the old post-horn, which still remains the watermark of this size of paper. When the General Post-office was established it was customary to blow a horn on the arrival and departure of the royal mails, and to this circumstance, no doubt, this watermark owes its origin. Fig. 5 represents the old post watermark, and Fig. 6 the one now used for this size of paper.

For the larger sizes of writing and account-book papers, the fleur-de-lis is used for a watermark, either plain as for copy (Fig. 7), or in an ornamental shield surmounted by a crown for the several larger sizes of demy, medium, super-royal, and imperial. These watermarks are, however, now very often either not used at all, or are superseded by the name of the manufacturer, which is often accompanied by the year in which the paper was made, or other words to denote the quality of the manufacture.

SANITARY ENGINEERING.—XVI.

DRAINAGE AND WATER-SUPPLY (*continued*).

In our last paper we gave a few particulars of the facilities available for the supply of small outlying villages and districts with a permanent supply of water, with some rough data as to consumption, outlay, etc. We now propose to deal with the same question as applicable to large towns, with some particular reference to London. As a matter of fact the present water-supply of London is almost entirely conducted on what is called the intermittent system—*i.e.*, the water is only laid on for a certain number of hours during the twenty-four; and this, of course, necessitates a provision in every house or place where water is required—the erection of a cistern which shall hold at the very least sufficient for the day's consumption. In many of the large northern towns the supply is what is called constant—*i.e.*, the water is always flowing day and night; consequently, no cisterns are necessary, but a different class of fittings are required. In various towns the consumption of water per head per day varies very considerably, and is dependent upon local circumstances. In Glasgow, for instance, the supply is brought from a distance and unlimited, and the authorities encourage, from a sanitary point of view, what would elsewhere be considered as a waste of water. As a result, the consumption reaches about sixty gallons per head per day, and we may here remark that this, of course, includes all the supply required for manufacturing purposes—an element which in all large towns represents a quantity equal, if not greater, than that required for household and sanitary purposes. In Manchester, where there is a supply of water on the constant system, but not the same unlimited resources as to quantity, very strict regulations to prevent waste are enforced, and under these the minimum consumption is twenty-one gallons per head per day.

To give an idea of the quantity required on the constant system, when there is no water required for manufacturing purposes, but only for household supply, we may quote a case of 500 small houses in Brighton, in which the actual consumption was found to be eleven gallons per head per day. London is partitioned out into districts among various companies—the New River Company, the East London Company, the Southwark and Vauxhall, the West Middlesex, Lambeth, Kent, Chelsea, Grand Junction, etc. Consumption varies materially in different districts, but it may be generally stated at between twenty and thirty gallons per day per head.

Legislation has recently been busy with the subject of securing a constant supply, which is much to be desired from a sanitary point of view, as in crowded districts, low neighbourhoods, and poor localities the arrangements for the necessary storage are frequently insufficient, and the health of the inhabitants suffers accordingly, especially in case of epidemics. We often hear also of a deficient supply of water in cases of fire in certain districts, and of delay in getting the water turned on: these difficulties are obviated by the system of constant supply. There is, no doubt, a general tendency in this direction, opposed, however, by the vested interests and conservatism of the water companies, who have at present (1872) in London the monopoly, though the mass of legislation upon the subject is very considerable; yet a little inquiry shows very clearly that especially upon the points of rating and charges we are practically in the hands of the companies. As the constant supply is gradually introduced, district by district, as will probably be the case if the Metropolis Water Bill of last session comes fairly into play, a very general change will be requisite throughout the plumbing appliances of the metropolis, a stronger class of taps, pipes, etc., being required to meet the increased pressure necessary for a constant supply, the majority of existing cisterns being rendered useless; while in places where the supply is now insufficient, the health, cleanliness, and comfort of the inhabitants would be considerably increased.

Another advantage of the constant supply is well known: in the northern towns it constitutes a handy motive power always at command, and the following are the data for calculation. We may take the average head of water of an ordinary company at about 100 feet. Water, as is well known, weighs about 62 lbs. to the cubic foot. We have, therefore, always at command a power representing a pressure of about 50 lbs. to the square inch. In Halifax, Bradford, and Leeds this power is constantly applied to presses, lifts, and small machines of all descriptions. In this respect London is far behind: the companies refuse in all cases to supply water direct from the main, but compel the introduction of a cistern; this neutralises, of course, the company's pressure as a motive power: as if, for instance, it is required to fit up an hydraulic lift, the head of water required to work it—say 50 to 80 feet—must be obtained from a cistern specially constructed for the purpose, with its separate service-pipe; all this outlay being, as we may say, arbitrary, as in the North it is not required. There the companies protect themselves by the common-sense plan of supplying water by meter; and these applications of water-power to mechanical purposes largely increase the demand for water, and therefore not only benefit the company, but by adding to the body of pure water passing through the drains are, as far as they go, an assistance to the sanitary condition of the town.

The principle adopted in this and many similar instances by the London companies must be false commercially, as the result is to limit the sale of water, the article in which they deal, and to curtail the amount that passes through the system of drainage generally. In the course of the next few years, however, we may look for some improvement in this respect. The system of consuming water by meter is all but unknown in London, while, strange to say, it is universally adopted with regard to gas, though this latter is far the more difficult to measure of the two, almost the only meters at work in the London districts being those used by the companies themselves.

It might possibly be supposed that there existed some mechanical difficulty in the measurement of water, but that is by no means the case. In an earlier part of this series (No. VII., under the head of "gas-meters") we gave an account of the various methods adopted for the measurement of gas, and in the case of water there is much less difficulty, as there is not the liability to vary from changes of atmospheric pressure. The motive power is the *pressure* of the supply. In this case the weight of the head of water, whatever it may be, can always be made to register the quantity supplied, and the cost of the machine need not necessarily be more than that of an ordinary gas-meter. One very good arrangement, called Kennedy's—and we believe the subject of a patent—has a piston which travels up and down in a cylinder of accurately ascertained dimensions: by an ingenious reciprocating arrangement the water is admitted alternately above and below the piston, and the rod above communicates a rotary motion to an arrangement of clockwork in a separate chamber out of the water, so that the number of gallons of water that pass through the meter is shown upon small white discs with black indicators, exactly similar to those we are already familiar with in gas-meters of various descriptions. There is no real reason why throughout London all water should not be bought and paid for by meter when required in such quantities for manufacturing purposes as to make it worth while; the only reason why it is not so is that the companies' arrangements are not made with that view, and consequently any inquiry for a large supply of water is met by a demand which almost invariably makes it better worth while to sink a well and even erect special pumping machinery than to pay the companies' charges.

As we before remarked, if the supply of London was ample and constant, the additional amount of pure water discharged through the drains would materially assist in their cleansing, as in all systems except the earth system systematic flushing is a most important element in the efficiency of a system of drainage, especially if it be adopted on the wholesale principle above mentioned as in use in Glasgow, for we may here note that in that city more than 100 per cent. in its rate of consumption only represents the waste water that is allowed to run away down the drains.

In localities differently situated, and not supplied from an inexhaustible natural head of water, but where every gallon of water used has to be raised either into an artificial reservoir or perhaps through a lofty syphon, a system of waste of this character would entail upon the water company an outlay at least twice as large as was really necessary, as the expense of raising the extra supply, as we may call it, must be paid for by the public somehow or other. Here, then, an altogether different set of motives come into play, and it becomes an object so to arrange the details of supply that while there is amply sufficient for all necessary and sanitary purposes, no outlay should be

incurred for raising water to be allowed to run away in waste. A glance at our last paper (p. 116), which explains the general methods for water-supply in limited districts throughout the country, will readily convey the idea of how heavily such a course would press upon the ratepayers of a poor village.

It is necessary in these cases to exercise all possible care in the economising of the supply, and our next paper will deal with cisterns, flushing cisterns, and the various mechanical appliances available for this purpose. Having arrived at that stage of our subject when the water is *laid on* to the house, we next propose to consider the methods of storing and distribution internally—*i.e.*, within the walls of the dwelling-house or warehouse—noting the sanitary precautions to be taken, and the best mechanical appliances available for various purposes.

TECHNICAL DRAWING.—LIX.

GOTHIC STONEWORK.

THE PERPENDICULAR ENGLISH PERIOD.

In the latter part of the fourteenth century, and towards the close of the reign of Edward III., symptoms appeared of a transition from the perfect and symmetrical style then prevalent, to one which displayed more elaborate and much richer work than its precursor, but was wanting in that chaste and elegant yet simple effect for which the Decorated period stands unequalled.

This style, when fully developed, is characterised by the exuberance and redundancy of its ornaments. In early examples, this enrichment was not carried beyond bounds, but in later times it becomes excessive, as if the chief aim of the architects had been to employ as much time as possible in the decoration.

From this profuse ornamentation, and minuteness of its ornamental detail, this style has sometimes been called the *Florid* Gothic, but it is more generally known as Perpendicular, in consequence of the peculiar arrangement of the tracery in the window-heads, which forms a very marked characteristic of the style. The beautiful flowing contour and curvilinear lines of the tracery, which characterise the Decorated period, were now suppressed by mullions running straight up from the bottom to the top of the windows, and transoms crossing horizontally. There was, however, a horizontal as well as a vertical tendency, for we find the high-pitched roof flattened, the arches depressed,

Fig. 509.

the drop, the four-centred, and sometimes square arches having been used.

The arch, in fact, became more and more depressed, the mouldings more and more shallow and ineffective. The drop-arch is perhaps the most prevalent, but as the period advanced, an arch began to be used which is not to be found in any other. It is described, as a rule, from four centres (Fig. 441, Vol. III., p. 17), and is called the Tudor arch. It occurs in every variety which the form is capable of taking. As a general rule, the centres of the upper portions of the arch lie immediately below those of the lower, but this is by no means universal. Sometimes the whole of the upper portion uniting the arcs of the ends is struck from one centre, in which case, of course, the arch becomes a three-centred one (Fig. 440), being, in fact, half of an ellipse, or rather of a figure approximating to an ellipse, since no portion of a true ellipse is a part of a circle. Towards the close of the style the curvatures of the upper portions are often found so slight that they can hardly be distinguished from straight lines, and in many instances, as the debasement of the style progressed, they were really straight. Ogee arches are of universal occurrence in the style, and foiled arches are very frequent. When the Tudor arch was not used, we generally

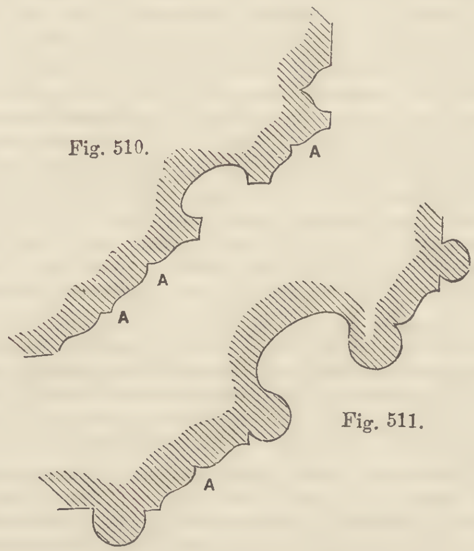


Fig. 510.

Fig. 511.

find the low drop arch. Other forms were employed, but of small size, and in combinations of window-tracery and panelling.

Fig. 509 is an arch from the south aisle of Chester Cathedral. The mouldings of this are continuous, and the soffit, or under surface of the arch, is panelled—both important features in Perpendicular arches.

The mouldings of this period are essentially different from those which preceded them, and have a character peculiarly their own. As a general rule, they are cut on a slanting or chamfer plane, and the groups of mouldings are separated by a shallow oval-shaped hollow, entirely different from those of the last period.

Fig. 510 is the moulding of the inner and Fig. 511 of the outer doorway of the south-west porch of Chester Cathedral. In each of these the shallow elliptical hollow is very conspicuous. The edges of this hollow were frequently rounded off into two small shafts, as in Fig. 511. The double ogee, or brace moulding, is seen at A, in each of the above examples.

The doorways of the early portion of this period had two-centred arches, but the characteristic form is the four-centred, enclosed in a square head, formed by the outer mouldings with a hood-mould of the same shape, the spandrils being filled with quatrefoils, flambeaux, roses, shields, etc. This square head is not always used inside the doorways, for an ogee canopy is sometimes substituted, or panelling is carried down to the arch, and there are also some small exterior doorways without the square head. Double doorways are not frequently used in this style.

The doors themselves were often covered with panel-work of a rich description, and sometimes with tracery in the head. This will be described in future papers devoted to Gothic woodwork.

PERPENDICULAR ENGLISH WINDOWS.

The general characteristics of the windows of this period—namely, the perpendicular mullions, and the horizontal transoms—have already been alluded to. The heads of the windows, instead of being filled with flowing ramifications, have slender mullions running from the heads of the lights between each mullion, and these have smaller transoms, until the window becomes divided into a series of small panels, and the heads of these

being arched, are trefoiled or cinquefoiled. In the later windows of this style, the transoms are often furnished at the top with a small ornamental battlement, and the mullions present a concave outline. It is believed that fully half of all the remaining Gothic windows in the kingdom are of this period. The large east window of York Cathedral is admitted to be the finest specimen. The example here given (Fig. 512) is from the north aisle of which another short slight mullion rises. These centres are repeated in the lower light on the right-hand side of the window, as well as in the light in the centre; but in this are shown at *c*, *c*, *c*, the centres from which the arcs that form the remaining cusps are struck. In the small light on the left-hand side in the upper part of the central compartment between the principal mullions are shown at *d*, *d*, *d*, *d*, *d*, the centres from which

Fig. 512.—WINDOW FROM NORTH AISLE OF NORTHFLEET CHURCH, KENT.

of Northfleet Church, Kent, and is chosen as illustrating most of the features described, whilst its simplicity will enable the student to copy it without much difficulty, although for his better guidance we may as well call his attention to marks in the illustration which serve to denote the centres from which many of the arcs employed in the construction of the window must be struck.

Thus in the large pointed light in the bottom of the window on the left-hand side are shown the centres *a*, *a*, from which the arcs that form the lower part of the lowest cusp on either side are struck, and the centres *b*, *b*, from which are described the arcs that form the pointed head of the light itself, from the apex are struck the arcs forming the cusps in the heading of this small light.

CHEMISTRY OF THE FINE ARTS.—V.

By Professor CHURCH, Royal Agricultural College, Cirencester.

WATER-COLOUR AND TEMPERA PAINTING—FRESCO—SILICEOUS PAINTING.

AFTER the full details already given as to the nature of the materials employed in painting, it will not be necessary to treat

the chemistry of the various processes in which they are used at any very great length.

Beginning with that method of painting which involves the least complication in the process of carrying it out, we may say a few words on water-colours. Here the finely-ground pigments mixed with small quantities of gum, sugar, etc., are merely spread over the surface of prepared paper or ivory. The binding material mixed with the colours prevents any particle from being subsequently removed by friction from the painted surface, but of course water destroys any work executed by this method, the binding material being dissolved, and no parts of the colour remaining but such as have sunk into hollows of the painted surface, or actually soaked into and stained it. In like manner water-colour drawings do not resist the injurious influences of sulphuretted hydrogen and of other gases. The minute protective film of gum which surrounds each particle of pigment is so far from being repellent of moisture that it actually absorbs it freely, charged as it may be with all sorts of dissolved impurities. Water-colour painting, then, offers but little chemical or mechanical advantage, so far as the preservation of the pigments against injurious influences is concerned. Nor must we omit to notice another source of weakness in this process—namely, the quality of the paper, vellum, or other material used as a surface for the reception of the colour. This material must be pure and strong, and free from the china-clay, pipe-clay, whiting, or plaster of Paris so largely used now to give weight and body to inferior papers. The less ash it yields when a trial piece is burnt, the better; many of the best sorts do not yield five parts in a thousand of ash. Nor should there be any specks of metallic iron from the machinery used in the manufacture, for these fragments will rust and discolour the paper round them with iron-mould stains. But the worst impurity in paper is a residual trace of the chloride of lime employed to bleach the pulp. This will destroy or injure most of the lighter tones of the pigments used. The purer the pulp, and the higher the quality of the rags used, the better will the paper be as to strength and as to freedom from excessive hygroscopic changes. Paintings executed in the older system of water-colour painting, as practised after the middle of the last century, were, for a long time at all events, merely tinted or stained paper. But with the progressive improvement of this branch of art by Turner and his contemporaries, there came also a wonderful development of the quality and richness of the pigments placed at the disposal of water-colourists. And within the last twenty years or so the practice of this branch of art has further changed by the gradually increasing use of opaque or body-colours. These are employed as freely as in oil-painting, though it is a question how far their use should be carried. For after all you cannot glaze over opaque white with clear tones in water-colour as you can do with such success in oil; so that the two methods of painting cannot really be assimilated in this important particular, while the loading of opaque colour in water-colour painting renders the work more liable to injury. It must not be supposed, from what we have said above, that the use of water-colours is of recent date. English artists painted with transparent colours and gum on linen cloth, at least as early as the fourteenth century; while the use of honey as a medium for the colours can also be traced back to mediæval times. But as we have said, in speaking of honey, its use is dangerous, owing to its absorbent power for water, and liability to change.

Before dismissing the subject of painting in water-colours, we may properly refer to the plans in use for preventing the greasiness of surface which paper and other materials so often present. Ox-gall would be a very unobjectionable material, were its colour less decided. Solutions of carbonate of soda, of borax, and of ammonia have been employed with a similar intention. The last-named compound seems to present some advantages over the others.

Tempera painting, or distemper painting, is by no means so simple a process, from a chemical point of view, as that just described. Not only does it demand the use of a prepared ground, but it involves rapid work, and sometimes requires subsequent treatment of the painted surface. Although in its widest sense tempera meant any more or less fluid medium with which pigments might be mixed, the term was generally employed in connection with the use of yolk and white of egg and parchment size. The process is a very ancient one, being mentioned even by Pliny, but in a damp climate and impure atmosphere cannot be regarded as satisfactory. The egg preparations were sometimes mixed with the milky juice (*latex*) of the fig-tree, sometimes with vinegar, wine, or honey. When size was employed, as in inferior works, it was prepared from washed parchment cuttings. The grounds were prepared with plaster of Paris, or size and whiting; upon these grounds the tempera colours were laid, while the finished painting was often finally saturated, in some parts at least, with boiled oil, or other kinds of varnish. Various contrivances were likewise adopted, especially in mural works, to secure the paintings from injuries arising from dampness or cracks in the walls or panels which were thus decorated. Linen, parchment, leather, and even leaves were often used for this purpose, being glued to the wall, and then covered with a coat of plaster or *gesso*, which was then saturated with warm parchment size, and thus made ready for painting. The generally unprotected condition of the pigments in true tempera pictures, the perishable nature of size and egg albumen, and the presence of sulphur in these organic substances, are the chief drawbacks in the use of this process.

Fresco.—This method of painting demands experience, and great technical as well as artistic skill. The particles of pigment are, it would seem, bound to the surface on which they are placed by a fine film of calcium carbonate (carbonate of lime), which forms upon them. A dry wall, pure sand and lime, both free from soluble saline matters, rapid work upon the fresh plaster, as well as a pure atmosphere, are among the chief conditions of permanence of works executed in fresco. There is, indeed, an inferior kind of fresco, called *fresco secco*, as distinguished from *buon fresco*, in which the wall plaster is allowed to dry, then rubbed down with pumice-stone, and moistened with lime-water just before commencing work. All the colours must be mixed with a little lime, prepared as described in Lesson IV. This method is adapted for ornamental or decorative rather than pictorial work, and under favourable conditions possesses some degree of permanence. Yet, compared with some of the other methods which remain to be considered, *fresco secco* cannot be regarded as of much importance.

In true fresco, or *buon fresco*, the following are the steps pursued:—Clean-washed quartz sand, as white, sharp, and uniform in grain as possible, is mixed with the old lime-putty described in our former lesson. The proportions used vary a good deal, but a usual mixture consists of two parts sand and one of lime. No plaster of Paris must be used in the preparation of this ground or *intonaco*. It must be laid upon a surface of tooled stone, brickwork, rough dry mortar, or roughened slate, previously moistened. An air-space behind the wall to be decorated is, where possible, a desirable precaution. It has been found that the sand may be omitted from the intonaco, if its place be supplied by crushed and sifted white marble, or even pumice. This substitution, however, may render the production of an even surface, to which an excess of lime has not been brought up by the float, somewhat difficult. Several coats of plaster are sometimes employed on the wall before the final one, which is prepared from day to day to receive portions of the design. The earliest and roughest coat may have small flint pebbles, etc., introduced into it without disadvantage. When the artist is prepared to begin work, the plasterer lays on a fine coat of intonaco, about one-eighth of an inch in thickness, upon that part only of the wall intended to be at once painted. Upon the wet, soft plaster the cartoon is laid, and the outlines and important details pounced in, or else indented into the plaster by means of a bone point. The artist then begins to paint, using hog's bristle and other hair brushes, bone or ivory palette knives, and palettes of sheet zinc. Tints, if much required, should be kept ready mixed, and may be preserved in earthenware pots, their exact tone when dry being ascertained by trying a little of each on a lump of dry umber or clay. It is impossible to describe in writing all those minute details of the practice of fresco which it is necessary to recognise in working. Success can only be secured by experience. Still it may be as well to note that the absorption of the moisture of the coloured tints by the ground has to be carefully watched. When this suction is too rapid the colours may very probably cease to become firmly adherent; a fine spray of lime-water, directed on to the part which has become too dry, has been found successful in remedying this accident. Before noting the pigments which may be safely employed in fresco, a word or two on the chemistry

of the process may not be unadvisable. The gradual absorption of carbon dioxide or carbonic acid gas by part of the lime in the ground which has not before been carbonated, seems to be the only chemical action which takes place in a fresco painting. But the assertion has been often made and repeated that a calcium silicate (silicate of lime) is formed in the course of time by the reaction of the lime and the silica of the plaster, and that the hardness of old mortars and similar preparations is mainly due to this cause. This idea is scarcely supported by the intense hardness which mortars made of lime and non-siliceous substances often acquire, nor indeed by the analysis of the old Roman and mediæval mortars themselves. It is possible that traces of such a silicate may be found when slaked lime and sand containing soluble silica remain long in contact. But the absence of mutual decomposition in the case of mortars made of dissolved water-glass and calcium carbonate renders extremely improbable any distinct union of lime and silica in the case of the ordinary mixtures containing sand used in fresco. Mr. Barff, however, states* that "lime, in the presence of water, acts upon the sand, dissolves and unites with some of the silica of which the sand is composed, and so a silicate of lime is formed; and this silicate of lime forms, I believe, the binding power in mortar."

In speaking of the colours which may be safely used in fresco, we may cite one simple test to which it is easy to submit them. Let a mixture of any doubtful pigment and some strong lime-white be allowed to grow gradually dry on a piece of earthenware. Then moisten it once or twice, and see if its colour remains as at first. Some inadmissible pigments may stand this test, but it is clear that all colours which do not stand it should be at once rejected. Ochres, cadmium yellow, cobalt yellow, some varieties of vermilion, and all the iron reds, chromium oxides, Guignet's green, some cobalts and ultramarine blues, with a large number of mineral and carbonaceous browns and blacks, may be safely employed in fresco. Vegetable and animal colours, with the exception of one or two combinations of organic acids with lime or magnesia, such as the euxanthates and picrates of these bases, cannot be safely used.

Siliceous painting.—The only kind of siliceous painting which can be regarded as of real practical importance, is that invented by the late Prof. Fuchs, and largely used by other German artists. Stereochromy—for such is the name applied to this process—has undergone several modifications in details since its first introduction. In giving an account of this most valuable method of painting, we shall describe the various steps of that form of the process which has proved to be the most successful.

A dry ground, free from sulphates, whether soluble or insoluble, and from all soluble matters of other sorts, is a necessary preliminary to a stereochromic painting. Some cements, such as Portland and Roman, which contain sulphates, have been, however, recommended as ingredients in the mortar-ground. Rain does not injure a picture painted by this method, but damp from behind or soluble saline efflorescences will do so. The ground may be a mortared wall, a surface of terra-cotta, a slab of stone or slate, or such a surface as would be suitable for fresco. Such of these grounds as exhibit joints or irregularities may be rendered available for use by means of a kind of cement or intonaco, which is made by mixing precisely such sand and lime as are best adapted for securing the surface desired, which should not be too smooth or too dense. Three parts of fine sand to one of lime is found to be the best proportion generally for the intonaco, which should be one-eighth to one-tenth in thickness, and which may be laid upon a mortar or undercoat of coarser quality: two undercoats are often used. A ground containing more sand, half fine and half coarse, has been found to give good results. A water-glass cement may be used instead of these mortars. It may be made by mixing sand, lime, zinc-white, and water-glass together, and laying the mixture on as an intonaco. Or crushed marble or limestone, or, better still, dolomite, or indeed any rocky material adapted to take the place of the sand, may be used instead of it in this cement, provided it be reduced to a proper and uniform degree of fineness in grain. The water-glass used in preparing this cement is that variety known as double water-glass, containing both potash and soda. Its preparation has been given in the preceding lesson. Unlike the water-glass which has to be subsequently employed for fixing the finished picture, the water-glass used in the mortar need not be rendered alkaline by the addition of caustic potash or soda. It will be none the worse for the presence of an excess of silica, introduced by shaking up with the solution some gelatinous silica recently precipitated. If the ground thus prepared, or any of the other grounds just mentioned, are not absorbent enough, they may be improved in this respect by burning a little spirits of wine upon them, a very useful expedient, in dealing with damp or non-absorbent walls, in many processes of mural decoration. Another way of curing a too dense or non-absorbent surface is by washing it over with a weak solution of phosphoric acid, or of monocalcic phosphate (biphosphate of lime). The plan, however, of saturating either the wall itself, or any of the mortars or other grounds just named, with soluble silicates or water-glass, though formerly recommended, is not now practised by any of the great German authorities on this process. It is still more important that the final coat of fine mortar, rich in fine sand but containing very little lime, and perhaps about ten or fifteen per cent. of zinc-white, should not be saturated with water-glass before commencing actual work. We are aware that Professor Barff gives (1870) entirely different directions, stating that both the under-ground and that which has to receive the painting must be saturated with soluble silicate. This, however, is a plan which the best stereochromic artists have long ago abandoned.

When the surface is dry it is prepared for work by moistening it with distilled water, or with lime-water, if the mortar has been spread some time, otherwise a solution of ammonium carbonate may be used. Then the colours, mixed either with distilled water, lime-water, or baryta-water, and containing, whenever possible, a little zinc-white, are laid on in the manner of fresco painting. Evenness of distribution is a great point here; the colours should not be loaded or laid on with an excessive impasto. White draperies may be painted in zinc-white, the only white admissible, or the ground may be left. Cross-hatchings are allowable, yet all the work should be done as much as possible before any part of the picture is submitted to the fixing process. The use of lime-water with the colours, and in wetting the wall, enables touches to be put in one upon the other without disturbing the paint already laid on. The fixing is performed with a syringe with cross jets, or with an apparatus in which a spray is produced by the violent commingling of air and water-glass solution. We have found that the little instrument called "l'odorateur," or "la bouffée," is admirably adapted to the work of distributing the fixing liquid upon the painted surface without disturbing the colours. It should be connected by an india-rubber tube with the nozzle of a pair of bellows or a blowing machine, the tube of the instrument dipping into a vessel of the fixing liquid kept warm. The fixing liquid is the double water-glass before referred to, and described in Lesson IV., or else pure potash silicate; but before it is used for our present purpose it should be alkalised by adding to fourteen parts of it, of specific gravity 1·2, one part of pure caustic potash solution, of specific gravity 1·33. Previous to use this liquid may be diluted with from one-half to twice its bulk of distilled water. Repeated applications of a weak water-glass are better than fewer applications of a more concentrated liquor. The fixed surface, when dry, must not shine. The success of the fixing process may be ascertained by passing a dry white cloth, and then the same material wetted, over the painting. If a little colour comes off from the rough points, it is of no consequence; but if anything like a smear occurs, it shows that the fixing process must be repeated. It is an advantage to the finished painting to be once and again sponged with warm distilled water, any soluble salts which may effloresce on the surface being thus removed. There is, however, a siliceous bloom which sometimes appears on stereochromic pictures, and this no mechanical or chemical process can remove. It occurs when over-silicated water-glass is used. This hard white opaque film may, however, be rendered transparent by a process which the author of these papers used ten years ago for this purpose, namely, the application of a warm solution of copal and paraffin to the clouded surface.

The colours used in stereochromy are used in fresco. Other colours also have been employed, both by English and German artists; a few pigments even of vegetable and animal origin having been found to possess an unexpected permanence.

* *Journal Soc. Arts*, xix., p. 160.

PRACTICAL APPLICATION OF THE FINE ARTS.—VIII.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

We again give two illustrations of various character, and somewhat advanced upon the previous designs. The one (Fig. 14) is a Pope in the attitude of blessing, and is in the *cinque-cento* style. It is impossible in a woodcut to give either the colours or even technical representations of colour which will be at all satisfactory. We will attempt, however, to describe the colours as they appear in the original sketch at the moment before the writer. The ornamental seat (except the cushion, which is red) and side ornaments are of a rather bright yellow, having a thinner coating of the flushing. The broad border and fringe will have to be of white glass for the sake of leaving the rows of pearls of that colour, but the whole of the rest will require the stain, as well as, of course, the shade in the necessary parts. The skirt below this, again, is also of rather thick white glass, which will only require delicate shading. This and the sleeves are supposed to be parts of the same garment, and are of the same colour, except the upper part of the left arm, which is the same light violet as the lining of the chasuble. This latter is of a deep gold tissue, and should be coloured accordingly, whilst the belt and brooch are supposed to be of pure gold, therefore of a brighter and clearer colour. Around and beneath the feet of the pontiff is the blue sky, and here again is room for the employment of taste in the choice of the blue.

Fig. 15.—THE LION OF ST. MARK.

heightened by the stain and by shade to a deep orange in the ornamental parts, the plain surfaces remaining the original colour of the glass. The interiors of the arcade beneath the seat are of a bright emerald or malachite green, and have within them a second line parallel to the leading, which is not given in the cut. The *nimbus* or glory round the pontiff's head is of a very light bright yellow colour, shaded off in rays so as to look like a sun behind the head. This is effected by the stain. The deeper-coloured cross is of a rather light crimson ruby glass, a little lighter and rather less crimson than the cassock or under-garment, which, of course, is the striking colour of the whole window. As this latter is the colour to which all the rest has to lead up, it will be necessary to choose this first, and to make all the rest subservient to it. This being a flushed glass, it is easy to select such glass as will have considerable modifications of the ruby colour: thus the prominent knee on the right hand of the figure should be lighter, If it were possible to obtain some of the old twelfth-century blue, that naturally would be the colour to be desired, but failing this we must obtain the nearest approach to it that is possible. Of course in the sky we would not introduce more shade than is absolutely necessary: a little will be required, and this may lead off gradually towards the leading. If much is used it will take away greatly from the transparency which is so greatly to be aimed at. But what cannot so well be effected by shading may be partially brought about by a choice of uneven glass and glass of a different tone. The greater the irregularity the pleasanter will be the effect. It remains to mention the clouds at the bottom: these will be white, and rounded off by shading. The staff is white with golden ornaments.

There is plenty of room for taste and ingenuity in the painting of this design. In the mere decorations much may be done with the stain in causing variety, and bringing forward the various ornamental parts. In the drapery,

again, we have only slightly indicated the principal folds, which must be carried out and deepened by the artist. The folds and embroidery of the chasuble, also, require attention, and in these matters the enthusiastic operator will be distinguished from the mere workman. In the face, hands, and foot there is opportunity again for the display of the utmost skill. The original, as it lies before us, shines forth with a countenance of bland meekness and amiability, which it will tax the ingenuity of the most skilled art-workman to imitate; but these things should be attempted—it may not always be with success, but many failures make a success; and every head carefully and conscientiously worked out, and every hand or even foot drawn accurately from nature, or copied from a great master, brings with it the power of execution, and the knowledge of form and anatomy, that were impossible without such practice. It is perfectly certain that a man who slurs over hands or feet will never accomplish the more observed, though not more difficult, countenances which will convey expression, thought, and beauty. The hands, too, must be made to accord with the age and character of the figure. The young, plump hands of a girl will not fit themselves to the figure and countenance of an ecclesiastic, nor will the hands of a priest be adapted to the habit of a boy. The warrior, the scribe, the youth, and the old man ought as much to be detected in the hand as in the face.

Fig. 14.—A POPE IN THE ACT OF BLESSING.—CINQUE-CENTO STYLE.

In our other diagram (Fig. 15), the Lion of St. Mark, we have rather a vehicle for a colour and a combination of agreeable lines, than either beauty of design or direct purpose of conveying ideas. There must be spots where the grotesque and colour, without ideas, is more suitable than more elaborate work. In this, too, will be found a lesson of ingenuity in placing the leads. It is possible to arrange the joinings in such a window as this that they do not in the slightest degree strike the eye; or, on the other hand, it is quite open to a misguided imitator of antiquity to avoid the natural divisions, and to insert just those which will most readily strike the beholder, we had well-nigh said, with horror and amazement. Deep primary colours will be found very suitable for the present design, as for instance a deep ruby ground, with a golden lion heightened with the stain in some places, a white or antique white (a greenish toned glass) label, with the lettering as black as possible, and a scroll pattern in brown, within concentric rings of a purplish white, a good blue and a white glass. A little shading may be introduced, but much would interfere with the transparency, which, however, would rather be heightened by a running line of scroll-work introduced with taste and elegance.

With these two examples we bring to a conclusion our Lessons in Glass Painting; we have endeavoured in the earlier chapters of the series to describe clearly and succinctly the various processes employed in the art, and our later lessons have been chiefly devoted to the practical application of the rules we have laid down. Of the importance of this branch of Art Manufacture it is hardly necessary to speak. Glass painting, which in this country had almost become a lost art, is now steadily reviving, and the workshops of many of our English manufacturers can show specimens which for correctness of drawing and beauty of colour are no whit inferior to the finest examples of Continental art. The lessons on glass painting will be followed by a series on mosaic work.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VII.

BY E. WYNDHAM TARN, M.A.

We shall now exemplify the foregoing rules by giving an imaginary dimension book and abstract, the quantities of which will hereafter appear in the general bill. In taking out quantities or measuring from the building, surveyors generally abbreviate several of the terms which have to be frequently repeated; thus, P. W. is put for "plain work," S. W. for "sunk work," M. W. for "moulded work," C. W. for "circular work," C. S. W. for "circular sunk work," C. M. W. for "circular moulded work," and so forth.

KENTISH RAG STONE.

	50 0 26 6	1325 0	24 inch rough random walling.
6)	6 6 3 6	136 6	Ddct.
		1188 6	
	50 0 26 6	1325 0	24 inch random coursed walling.
5)	6 6 3 6	113 9	Ddct.
	8 6 3 6	29 9	Ddct.
		143 6	
		1181 6	
2)	50 0 26 6	2650 0	Pointing in blue ash mortar.
11)	6 0 2 6	165 0	Ddct.
	8 0 2 6	20 0	Ddct.
		185 0	
		2465 0	
200)	2 0 1 3 0 9	187 6	C. bondstones.

PORTLAND STONE.

	30 0 26 6	795 0	4 inch ashlar facing.
6)	5 6 2 6	82 6	Ddct.
		712 6	
50)	2 4 1 6 1 0	175 0	C. bondstones.
15)	3 9 1 0 0 4	18 9	C. spandril steps.
15)	3 9 1 2	65 8	Half-sawing.
15)	3 9 1 7	89 1	P. W. to top and front.
15)	3 9 1 2	65 3	Add soffit.

15)	3 9 0 4	18 9	S. W. to rebate.
15)	3 9	56 3	Chamfer 2 inch wide.
	No. 30 holes drilled for balusters.		
	,, 15 cutting and pinning ends of steps into wall.		
2)	5 9 1 6 0 5	7 2	C. winders.
2)	5 9 1 9	20 2	Half-sawing.
2)	5 9 1 6	17 3	P. W. top and front.
2)	5 9 1 9	20 2	C. S. W. soffit.
	No. 2 ends cut and pinned into wall.		
	3 9 3 9 0 7	8 4	C. landing.
	3 9 3 9	14 1	P. W. to top and bottom.
	3 9 0 7	2 2	Add front.
	7 6	7 6	Cutting and pinning in wall.
	15 6 3 0	46 6	3 inch balcony.
	15 6 6 0	93 0	P. W. top and bottom.
	22 0 0 5	9 2	M. W. front and ends.
	22 0	22 0	Throating.
	6 0	6 0	Joggled joint to 3 inch landing.
5)	4 4 1 0 0 6	10 10	C. sills.
5)	4 4 1 0	21 8	Plain bed.
5)	4 4 1 5	30 8	P. W. top, front, and projection.
5)	3 6 0 7	10 [illegible]	S. W. top.
5)	4 4	21 8	Throating.
	33 0 3 0 1 3	123 9	C. cornice.
	33 0 1 3	41 3	Half-sawing.

2)	30 0 1 6	90 0	Plain bed.
10)	3 0 1 3	37 6	Add joints.
	36 0 1 6	54 0	S. W. top.
	39 0 2 3	87 9	M. W. front.

No. 4 mitres to cornice, 2 ft. 3 in. girt.
,, 2 stopped ends to ditto.
,, 10 plugs, 10 lbs. lead.

10)	0 7	5 10	Groove for lead.
	30 0 2 0 0 9	45 0	C. blocking.
	30 0 2 0	60 0	Half-sawing.
	31 6 2 0	63 0	P. W.
	30 0 0 9	22 6	Add.
10)	1 0	10 0	Groove for lead.

No. 10 plugs, 10 lbs. lead.
,, 20 slate dowels in cement.

2)	7 6 1 1 1 1	17 7	C. columns.
2)	1 1 1 1	2 4	Plain bed.
2)	7 6 3 3	48 9	C. S. W.
4)	3 3 0 6	6 6	Add.
2)	2 0 1 9 1 9	12 3	C. capitals.
4)	1 9 1 9	12 3	Plain beds.

No. 2 carved capitals to design.

2)	1 0 1 6 1 6	4 6	C. bases.
4)	1 6 1 6	9 0	Plain bed.
2)	3 6 0 9	5 3	C. M. W.
2)	6 0 0 3	3 0	P. W.

No. 10 slate dowels in cement. 20 mortice holes.

7)	1 7 1 6 1 1	18 3	C. voussoir to arch.
7)	1 7 1 1	12 0	Plain bed.
7)	1 7 1 2	12 11	S. W. bed.
7)	1 6 1 3	13 1	C. W. soffit.
7)	1 3 0 9	6 7	C. M. W.
6)	6 6	39 0	Lintels, 9 in. × 9 in.
6)	6 6 0 9	29 3	Plain bed.
6)	6 6 1 6	58 6	P. W.
6)	4 6	27 0	Chamfer.
	25 0 1 6 0 6	18 9	C. coping.
	25 0 1 6	37 6	Plain bed.
8)	1 6 0 6	6 0	Add joints.
	25 0 1 6	37 6	S. W. top.
	25 0 1 0	25 0	P. W. front.
2)	1 6 0 6	1 6	Add ends.
	53 0	53 0	Throating.
8)	0 3	2 0	Groove for lead.

No. 8 plugs, 4 lbs. lead.

50)	3 1 1 10 1 1	305 10	C. quoins.
50)	3 0 1 9	262 6	Plain bed.
50)	1 9 1 1	94 10	Add joints.
50)	4 6 1 0	225 0	P. W. front.
50)	11 0 0 6	275 0	M. W.

YORK STONE.

6)	4 4	26 0	3 in. weathered, throated, and tooled sill, 9 in. wide.
			No. 12 fair ends to ditto.
	51 0	51 0	3 in. tooled coping, 12 in. wide, weathered and throated.
			No. 2 fair ends to ditto.
	4 6 2 6	11 3	7 in. sink.
			No. 1 rounded corner to ditto. „ 1 rebated hole to ditto.
4)	1 6 1 6	9 0	3 in. template.
	22 0 2 3	49 6	3 in. core for cornice.
6)	3 6 1 6	31 6	3 in. rubbed hearths.
	12 0 9 0	114 0	2½ paving.
	43 0	43 0	Cutting edge to ditto.

PAVING.

	30 0 12 6	375 0	Elland edge sets in sand and grouted.
	30 0	30 0	Granite curb 12 × 6.

MARBLE.

4)	3 6 1 6	21 0	2 in. polished slabs to fire-places.
2)	13 0 0 7	15 2	1 in. mantel, jambs, and shelf.
			No. 4 console chimney pieces, value 10 gs., P. C.

ABSTRACT.

Kentish Rag.	Portland Stone.					York stone.		Paving.	Marble.
Cube bond.	Cube.	Superf.		Run.	Nos.	Superf.	Runs.	Superf.	Superf.
ft. 187 6 Superf. 2¼ in. rough random walling. 9)1188 6 132 yds. 2¼ in. coursed walling. 9)1181 6 131¼ yds. Pointing in blue ash mortar. 9)2465 274 yds.	ft. 175 0 18 9 7 2 10 10 123 9 45 0 17 7 12 3 4 6 18 3 18 9 305 10 757 8 Landing. ft. 8 4 Superf. 4 in. ashlar ft. 712 6	Half Sawing. ft. 65 8 20 2 41 3 60 0 2)187 1 93 7 Plain bed. ft. 21 8 127 6 2 4 12 3 9 0 12 0 29 3 43 6 262 6 94 10 614 10 P. W. ft. 154 9 17 3 16 3 93 0 30 8 85 6 3 0 58 6 26 6 225 0 710 5	S. W. ft. 18 9 10 3 54 0 12 11 37 6 133 5 M. W. ft. 9 2 87 9 275 0 371 11 C. W. ft. 13 1 C. S. W. ft. 20 2 55 3 75 5 C. M. W. ft. 5 3 6 7 11 10 3 in. balcony. ft. 46 6	Lintels 9″ × 9″, in lengths of 6 ft. 6 in. ft. 39 0 Groove for lead. ft. 5 10 10 0 2 0 17 10 Chamfer. ft. 56 3 27 0 83 3 Cutting and pinning to landing. ft. 7 6 Throating. ft. 22 0 21 8 53 0 96 8 Joggle to 3 in. landing. ft. 6 0	Carved capitals to design. 2 Mortice holes. 20 Holes for balusters. 30 Cutting and pinning ends of steps. 15 2 17 Mitres to cornice, 27 in. girt. 4 Stopped ends to ditto. 2 Plugs. 10 10 8 28 Slate dowels in cement. 20 10 30 Lead. lbs. 10 10 4 24	7 in. sink. ft. 11 3 3 in. rough in templates, etc. ft. 49 6 9 0 58 6 3 in. rubbed hearth. 31 6 2½ paving. ft. 9)114 0 12¾ yds.	3 in. sill, 9 in. wide, weathered and throated. ft. 26 0 3 in. coping, 12 in. wide, ditto. ft. 51 0 Cutting edge of paving. ft. 43 0 Nos. Fair ends to sills. 12 Fair ends to coping. 2 Rounded corner to 7 in. sink. 1 Rebated hole to sink. 1	Elland edge sets in sand and grouted. ft. 9)375 0 41¾ yds. Run. Granite curb, 12 × 6. ft. 30 0	2 in. polished slabs. ft. 21 0 1 in. ditto. ft. 15 2 Nos. Console chimney-piece, 10 gs., P.C. 4

GREAT MANUFACTURES OF LITTLE THINGS.—VI.

BY CHARLES HIBBS.

NEEDLES.

A PLEASANT little country town on the borders of Worcestershire, situate in the midst of the finest scenery in the Midlands, is the present seat of the needle manufacture. Why it should have settled down in that precise spot, after migrating from place to place, with something of the aimlessness which characterises the wanderings of a tramp, it is not easy to explain. But whatever the cause, it cannot be otherwise than gratifying to find a thriving manufacturing community planted in the midst of corn-fields and cattle pastures, enjoying the benefits of pure air and ample space, instead of being crowded into an overpacked town, where breathing-room is an almost unattainable luxury. Redditch, which, according to the latest census, has about 7,000 inhabitants, all of whom depend, in some way or other, upon the needle manufacture, with the exception of some few who are engaged in the making of fish-hooks and pins, has established a reputation throughout the whole world, not inferior to that enjoyed by Sheffield and Manchester for their special productions. Though it has a half-

ral population, not free from that bucolic fixity of idea which fers a passive resistance to progress, the improvements in the edle manufacture have quite kept pace, especially of late ars, with the mechanical advances of the time. A Redditch edle, smooth, clear-eyed, gently tapering to a point of extreme eness, possessing the happy medium of springiness and gidity, and as straight as a Parthian arrow, is as near per-ction as it is possible to be. The processes of its production, hich we now proceed to describe, differ in many respects from ose in use only a few years ago.

The steel wire of which needles are made is procured prin-pally from Sheffield. That centripetal force which tends to ncentrate the various factors of production into one spot is t work in the little town of Redditch, and there is some talk f a wire-mill being established, to render it independent of at source of supply. The wire comes in coils, and is first ut up into lengths sufficient for two needles. A strong pair f shears is fixed in an upright position, and the coil being ung on a hook to relieve the workman of its weight, is cut hrough, and afterwards fed up to the shears by his left hand, hile his right holds the gauge which measures off the length. he handle of the shears is worked by his thigh. The wire is oft, and the shears will cut through 250 wires of medium auge. These short pieces have then to be straightened, as ach partakes of the curvature of the coil from which it has een cut. The method of doing this is curious. A number of ieces, say 20,000, are placed within two rings, which hoop hem about half-way between the centre and the extremities. hey are not packed tightly in these rings, but lie loosely, the pace being about three-fourths filled. All is then heated to a ull red, and the rings being made to stand upright on a slab f iron, the straightener takes a bent steel bar by its two ends, nd pressing heavily with it on the middle part of the wires, etween two rings, rolls them over each other by a long sweep rom side to side. When he has operated sufficiently on those t the top, he makes the rings roll on a little way, and another ortion of the wires comes under the rubber. Thus he goes on, ntil every individual wire is perfectly straight. The next peration is to point them. The former method of doing this as very similar to the old process of pointing pins, described n our last article. The workman sat before a dry grindstone evolving at high speed, holding between the palms of his ands from fifty to a hundred needles, which he rolled back-ards and forwards while he pressed their points upon the tone. It was a murderous occupation. The fine dust found ts way to the delicate air-passages of the lungs, clogging them p; and was so deadly in its effects that no pointer could look orward to more than ten or fifteen years of life after he began o follow his trade. About twenty-five years ago, the use of he Sheffield grinder's fan, introduced by Dr. Holland, greatly essened this risk; but strange to say, the improvement met ith a vigorous opposition from the very men it was intended o benefit. The certainty of speedy death had operated to their dvantage in one way; it had kept up for them a high rate f wages, by limiting their numbers, and frightening new omers. A needle-pointer could earn as much as a pound a ay during that brief period when his powers were at their best. f the occupation were rendered harmless, the rush of com-etitors from other less lucrative branches would soon reduce is wages to the common level, and his dull selfishness regarded his as an invasion of his monopoly. He resented as an injury o himself the merciful expedient which would deprive him of he opportunity of selling his life for gain. The fan-blower xhausted the air from a tube with a funnel-shaped mouth, laced at the back of the grindstone, and the particles were rawn down into a box underneath. Despite opposition, the nvention became universally applied, and pointing was as armless as any other branch of the manufacture. Another evolution was impending which was much more fatal to the nterests of the pointers. This was the introduction of the eedle-pointing machine, generally supposed to be a German nvention, but of which the first crude idea had appeared in machine of English construction some years before. This atter was only partially successful, but there was enough in t to alarm the hand-pointers, who, on its becoming disused, lubbed to purchase it, and broke it up solemnly on Redditch Green. The present machine is very beautiful in its con-struction and effective in its working. The grindstone, which is broader than that used for hand-pointing, is turned with the most perfect accuracy, and its periphery is hollowed out like that of a pulley, only much shallower, and the true arc of a circle. An iron wheel, covered with vulcanised india-rubber, revolves over this at an oblique angle, very slowly, being so hung as to traverse the hollow of the stone without touching it. A steel band encircles this wheel underneath, between it and the stone, which still is not actually touched, though the band lies very close to it. Down an inclined plane at the side a man feeds the wires on to the wheel, which takes them down between itself and the steel band, causing them to rotate at the same time, and bringing their points gradually to bear on the stone. At first the extreme points only are touched, but as the slowly-rotating wheel pursues its diagonal course, the bevel extends up the shaft of the needle, and gives it the swelling taper which so much delights the seamstress. As they come up to the opposite end of the steel band, the wires drop off into a trough, and are ready to be put through again for the purpose of pointing their other ends; each wire, be it remembered, having to form two needles. Forty thousand needles can be pointed in an hour by each of these machines. A fan-blower acts upon each machine, and the shower of sparks, which represent fine particles of steel, are drawn down the tin tube by a strong draught. A machine of similar construction brightens the middle part of the wires, which are black and scaly from having been heated red-hot in the straightening, the object being to make a clean place for the stamp to act upon, and form the two heads. This is the next process. A pair of delicately-cut bright dies gives the shape of the heads, the indentation for the eyes, and the gutter or groove, if any, which leads up to the eyes. There are perhaps as many as thirty different shapes of eyes known to the trade, each being recommended for one quality or another, though the office of all is merely to hold a bit of thread. There are round eyes, square eyes, and oval eyes; eyes egg-shaped, pear-shaped, and pippin-shaped; and many others. The stamp flattens out the soft steel on either side, and the heads of the two needles appear as if embossed in high relief from a small flat plate. A man stamps them one by one, having acquired from long practice great dexterity in placing them quickly on the bed; and 50,000 or so is but an ordinary day's work. The next operation is to complete the puncture, which is done by a girl at a press. The tools are made to work with great nicety, and both holes are cleanly pierced with one blow. The next job is to thread or spit the double needles on wires passed through the eyes. This was formerly done by very young children, and when the Factory Act came into operation and prohibited their employment, there was an outcry that the prosperity of Redditch was ruined for ever. But the needle district still stands where it did, and its shadow has not been lessened by the emancipation of the little ones. A number of needles being spitted and pushed up close together, are handed to a man whose business it is to file off the flattened projections left by the stamp. He places them flat down on a strip of wood before him, and a couple of steel clips, tightened down by a treadle under the bench, hold the points firmly while he dresses first one side and then the other of the whole row. The double needles then easily break asunder in the middle, each side being still spitted on its own wire. He then seizes the shafts with a pair of wide-jawed pincers, and holds them over a peg while he files up the row of heads, rounding them into shape. The next step is to smooth the insides of the eyes, which, having been cut out with press tools, have necessarily sharp edges which would infallibly cut the thread. For this purpose they are again threaded upon fine wires which fit them loosely, and which have been previously roughened and hardened. When a number of such wires have been threaded, they are fixed in a frame, the needles dangling loosely down, and the machinery being set in motion, the frames are shaken backwards and forwards as a gardener would shake a riddle. This of course sets all the needles dancing and wagging with great activity, and in time all the corners are worn off, and the eyes become burnished smooth and clear. This process is very amusing to witness. The needles are now ready for the hardener, whose business it is to get them to the temper which will render them trusty in the hands of the housewife. He places them on iron plates of suitable shape, and heating them to the proper degree of redness in a furnace, turns them over into a liquid composition in which oil is the principal ingre-

dient. Great care is requisite in watching the heating of the needles, and an unskilful workman would soon spoil a great quantity. Being afterwards washed and dried, they are brought down to the requisite temper by re-heating, in the same way as are steel pens. They have then to be picked over for "crooks." Women's fingers are best for this work, being more delicate in the sense of touch. A perfectly level slab of stone, of some smooth texture, is laid upon the bench, and the operator, feeding down the needles rapidly with her left hand, rolls them over one by one under the fore-finger of the right upon the stone. If the needle rolls smoothly and evenly, it is straight; if not, it is quickly cast aside as crooked. The bent ones are afterwards straightened one by one by taps of a very small hammer upon a tiny anvil. It was at one time the usual practice to harden the needles in water, and the sudden transition from heat to cold caused many of them to go crooked, thus furnishing occupation for the straighteners. When the oil bath was substituted, crooked needles became the exception, and the introducer of the method was instantly pounced upon as an enemy, and driven from the town by repeated mobbings. After this stage the needles are "weighed up for the mill," a purely warehouse operation, which has nothing to do with their manufacture, but which is nevertheless highly necessary for the manufacturer, who tests by this means the amount of waste which has occurred since the first process, and is enabled to judge of the quality of the steel he is using. The scouring mill, which comes next, marks a very important stage in the making of the needle. The method of scouring in the very early times of needle-making was primitive enough. The needles were wrapped up in buckram, with emery dust and olive oil, and rolled to and fro under the feet of the workmen as they sat at work at some other process. Now, extensive mills, worked by water or steam power, are used for the purpose. Long rolls of coarse cloth or canvas, each containing about 50,000 needles, with a small quantity of powdered quartz and soft soap, are bound up tightly along their whole length, and well fastened at the ends. Two of these rolls are placed in each machine, of which there may be twenty or thirty in the mill. The machine is a sort of mangle, having a massive fixed bed faced with iron, and a heavy slab of wood resting upon it, under which the rolls are placed. Heavy wooden arms, moved by cranks in the main shaft, work these slabs to and fro, they being weighted according to circumstances. For no less than eight days are the needles thus mangled, but their canvas wrappers are changed several times during that period, and they receive fresh dressings of scouring material. If the object were merely to brighten the needles, one would think that some easier and quicker agency could be found than the ponderous creaking machinery of the scouring mill, but this rolling of the needles together under heavy pressure assists in giving them a contour—a perfect swelling rotundity of form—which is said to be unattainable by any other means. After being again washed and dried, they are taken into the "bright" shops, which is a sort of promotion in their career. Here, for some few stages further, they are turned over to the delicate fingers of women, whose first care is to reduce them to order. When they come from the scouring mill, of course the needles are all lying in a confused heap, and before anything more can be done with them, they must be "evened," or placed in decorous rows side by side. For this purpose, the girl puts a small shovel-full into a shallow pan, which she shakes gently with one hand, all the while stroking the needles with a sort of metal paper-knife into a longitudinal direction. In a short time they all fall into regular order, and are then carefully lifted out and placed upon narrow strips of box-wood, with ledges at the ends to keep them from rolling off. The next business is technically called "handing," and consists in extracting from the heap those which are slightly longer than the rest. With all the care exercised in cutting the wires in the first instance, and in the after pointing and dressing, the needles will differ in length by some minute fraction of an inch, and the object of this process is to sort them. The needles, as they lie upon the strips, are gently patted at the ends with the iron paper knives to level them, and then the girl touches them lightly on both sides with the ball part of the palms, the longest needles sticking to her hands, and allowing her to work them up gently through the heap to the top, when they are carefully lifted off and placed aside. She then tries again for the next longest, and so on, there being perhaps as many as ten "handings" from a heap. An unpractised eye could not detect any difference between the longest and the shortest, but this nicety is necessary for the final arrangement of the needles in those small paper packets in which they reach the consumer. When they are well handed and sorted, they are still in some little disorder, the points being some one way, some another, and this has next to be rectified. A girl wraps a piece of wash-leather or cloth round her right fore-finger, and backing up one end of the needles with her metal paper-knife, touches the other ends lightly with her clothed finger, and pulls out all those whose points stick in the material; the heads, of course, not sticking in, are left behind. The well-arranged needles have now to be picked to see if any defective ones have accidentally crept in. They are rejected for damaged heads or points, for "flecks" (little blacks or specks in the metal), and for crooks. The girl lets them fall towards her down an inclined plane one by one with great rapidity, and as the slightest defect catches her eye, the offending needle is instantaneously jerked out. It would be difficult to tell, from an examination of any rejected needle by itself, why it was cast out; it requires to be seen in connection with the perfect ones for its fault to become apparent. The next thing is to "blue" the heads for the purpose of softening the needle a little more at that part to prevent them breaking off across the eye. The usual method in the trade has been to lay them evenly upon a stone, with the heads slightly hanging over, a red-hot iron being brought up against them, and held till they turned colour. A much more elegant method has now come into use, and the heads are beautifully blued by a self-acting machine. The needles are fed from an inclined plane to the circumference of a wheel, which has transverse grooves upon it, each capable of taking up one needle. A band keeps these needles in their places while the slowly-revolving wheel takes their overhanging heads through the flame of some gas-jets, the time occupied in traversing being just sufficient to give them the colour. It then deposits them on an endless moving band, which carries them back again, and drops them evenly into a trough. After this they get into the hands of men for the final touches, viz., grinding, by which the outward shape of the head is nicely rounded and finished; setting, *i.e.*, sharpening the points, in the sense that a razor is said to be set; and polishing, by which an exquisite glaze is put upon the needle from end to end. All these processes are performed upon little stones and "bobs," no larger in diameter than a cotton-reel. As a last attention, they are well rubbed between two pieces of buff leather, lest any moisture should remain upon them from the hands of the workpeople, and are then ready for the packing room.

A great sensation was made in the trade some years ago by the introduction of "drilled-eyed needles," which took the market wonderfully, on account of their superior appearance. They were not really drilled, but only countersunk a little on both sides, the hole having been previously pierced through with a press. It was soon discovered that they cut the thread, the countersinking having left a ridge in the middle. A great many of these so-called "drilled eyes" are made now, but as a matter of course, the process is only applicable to round eyes: those of longitudinal and fancy shapes have to be treated in a different manner. A small buff "bob," stuck full of short spikes or points of wire, revolves very rapidly. The eyes of the needles are pressed against this, and it rounds down the sides and edges of the orifice very effectually. This process is called "curing."

It is pleasant to see the large and lofty workshops, with windows looking over miles of prospect, of some of the larger factories. The one we had the pleasure to visit—that of Messrs. S. Thomas and Sons—is of modern build, and not only contains the newest and most improved machinery, but seems to have been specially constructed with a view to the health and comfort of the workpeople. All is beautifully clean, and every precaution is taken to keep the atmosphere pure and wholesome. A large workroom, which in Birmingham would be made to hold at least fifty workwomen, is there tenanted by not more than a dozen. They get up the very best work, as our account of the precautions taken in the finishing processes sufficiently shows. It must not be supposed that *all* needles are prepared for the market with such extraordinary care; a great many of vastly inferior quality are doubtless manufactured, and with far inferior appliances, but the readers of this work will be most interested in the newest and best developments of the trade. It is to the

enterprise of this firm that the town will be indebted for its new wire-mill. They make their own machinery, and, up to a recent period, even their own gas; and their extensive manufactory is in every respect a model.

Not less than 100,000,000 needles are made weekly in the Redditch district. Every housewife can now obtain, at a very moderate price, an assorted stock of these useful implements, to suit any purpose for which she has occasion to use them.

The English ladies derived their needles from Spain and Germany until Queen Mary's time, when, as Stowe relates, "a negro made fine Spanish needles in Cheapside, but would never teach his art to any." With him died out the secret; but it was introduced in the next reign by a German, and other needle-makers also came from Normandy. It was first established as an English manufacture at Long Crendon, in 1650. From thence it travelled gradually through one or two smiling villages in Warwickshire, as though feeling for its final resting-place, which it ultimately found in Redditch. There it is likely to remain. The only competitors in foreign markets are the Germans, but the quality of their goods will not bear comparison with the productions of Redditch. For cheap and common articles the German price cannot be touched.

MINING AND QUARRYING.—XVIII.

BY GEORGE GLADSTONE, F.C.S.

TIN (*continued*).

TIN PLATES—TERNE PLATES—PROCESSES OF TINNING OTHER METALS—SILVERING GLASS—OTHER APPLICATIONS—INCREASING VALUE OF TIN.

ONE of the most important applications of tin is due to the faculty it possesses of adhering to the surface of iron, and of forming an actual alloy with that metal, which is brought into action in making tin plates. By this union of the two metals a thin sheet can be produced which shall have the strength of iron, but which shall not be liable to rust as that metal is; while on the other hand it has a strength far exceeding that of tin. Nevertheless, the manufacture of tin plates in this country only dates back about 150 years, though it was adopted in Germany a century before.

The foundation is iron, which has to be rolled out into very thin sheets. A thoroughly tough and uniform metal is required for the purpose, and much care is therefore exercised in making the sheet iron. Charcoal plates, which are the best (the others being called coke plates), are so named because charcoal is used in the finery. The refined bar is subject to the hammerings, rollings, etc., which all finished iron has to go through; and is then ready to be rolled out to the size and thickness required in this manufacture. Here it is rolled, doubled up, and re-heated over and over again, the greatest possible care being taken that no scale shall form on the surface of the iron, because if this should be rolled into the metal it will produce a roughness of the surface in the subsequent pickling, which will injure the quality of the finished plate. With this object the temperature of the re-heating furnace is kept low. The edges are then trimmed, so that the plates shall be of the exact size ultimately required; there being five different sizes common in the trade, as well as variations in the thickness of the metal.

The plates are then set edgewise in a bath containing the pickle, which consists of a weak solution of sulphuric or hydrochloric acid, usually in the proportion by measure of 16 of water to 1 of the acid; the pickle is gently warmed over a fire until all the oxide is removed from the surface. The acid used for this purpose should be quite free from arsenic, for fear of which sulphuric acid made from pyrites should be avoided. After this the iron sheets are carefully washed, and then put into the annealing pots, which are closed down and then exposed to a bright red heat in a reverberatory furnace. The next process is to roll them cold, between highly-polished rollers, after which they pass through a second annealing and bath of pickle, by which time a perfectly smooth and bright surface is attained.

Thus prepared, the plates pass into the hands of the tinman, whose business it is to give them the coating with the more valuable metal. For this part of the operation a series of cast-iron vessels are required, which may be conveniently arranged in a row as shown in the accompanying diagram (Fig. 11) and the ground plan (Fig. 12). The plates, after being scoured and rubbed clean, are put into the pot marked A, which is filled with grease, kept in a liquid condition by the heat from the fire below, and the flue which passes round the sides, as shown in the drawing. When thoroughly coated with the grease they are passed into the tin-pot B, which contains a bath of melted tin, the surface of which is also preserved from contact with the air by a superficial stratum of melted grease. Some pieces of wood are immersed in the tin to separate any impurities there may be, upon the same principle as that already described in our last paper, when treating of the refining of the metal. From this they are removed to the wash-pot C, which is made in two compartments, both containing melted tin and grease, but kept at a lower temperature than that in B. The quantity of tin used in both these is superior, the best of all being in the smaller (left hand) compartment of C. When the plates are taken out of the larger compartment, they are laid upon the table G, and carefully rubbed on both sides with hemp, after which they are dipped into the smaller bath to receive a final coating for the purpose of obliterating any marks made in the rubbing. The next pot, D, is filled with palm-oil and tallow, which is kept just hot enough to melt off all superfluous tin, the plates being stood in it on edge that the tin may be free to run down to the bottom of the pot. The next, E, is the receptacle in which they are left to cool; and the last, F, is the list-pot, in which only the lower edge of the plate is inserted, so as to melt off the beading of tin which will have accumulated there while standing in the grease-pot, D. The plates have then only to be cleaned with bran and rubbed with flannel, and they are ready for packing in boxes for sale.

There are a variety of marks indicative of the size and weight of the plates which make up a box, and which are common to both descriptions—charcoal and coke plates. They are known as commons, C; and crosses, X; with common doubles, C D; and cross doubles, X D; and common and cross small doubles, C S D and X S D respectively; the further subdivisions being indicated by numbers from one to four. A box of the first two categories contains 225 plates; of the common and cross doubles, 100; while of the small doubles 200 constitute a box.

Tin can also be applied with advantage to other surfaces than iron. In a former article galvanised iron and its properties have been described, and this may serve also as a basis for a tin coating. In such case the surface of the zinc must be freed from all oxide, by immersion in a weak acid pickle, and the sheets then dipped as above described in a tin bath, the surface of the molten metal being protected from oxidation as before by the surface being covered with melted tallow or oil.

Lead may in like manner be coated with tin: in both cases it is desirable to warm the inferior metal to a point nearly approaching that of the melted tin. It is capable of being rolled out into thin sheets after the coating has been added, and if any flaws should be found on the surface after such operation, the plate is usually dipped again.

Small iron articles are often tinned in another manner. The goods must be cleaned of all rust by the action of an acid as usual, then quickly washed, and placed at once in a jar or close vessel along with some tin and chloride of ammonium. The jar is then placed in a furnace and heated, being kept in motion all the time, so as to bring the tin into contact with all parts of the articles which are to be coated. When taken out of the vessel they are washed with water to remove the sal-ammoniac, and rubbed up with hot bran or sawdust to give them a brighter surface.

Any of the fusible alloys of tin described in the preceding article will serve as a coating instead of the pure metal.

Terne plates, for instance, are coated with an alloy of tin and lead in any proportion, varying from one-third to two-thirds of tin. They do not possess the brilliant surface of the real tin plate, but are useful for various purposes, such as roofing, for which the other article is too expensive. Terne plates are sent to Canada in considerable quantity, where they are applied to the purpose just named.

Copper vessels are often tinned inside, especially those intended to be used in cooking. On account of their shape, and because only one surface is to be coated, a different plan is adopted in this case. The surface to be tinned is first sprinkled with chloride of ammonium and then heated, which causes the salt to dissolve and enter into combination with any oxide on the

surface of the copper. The whole of it is rubbed during the heating until every part is quite bright and clean. The copper being still maintained at a temperature sufficient to melt tin, some of this latter metal is placed in contact with it, and as soon as it is sufficiently melted it is rubbed by means of a pad all over the surface of the copper. The two metals combine, forming a true alloy. If the workman should be lavish of his material, and make the coating too thick, the outer surface will be pure tin, which can be melted off again without affecting that portion which has entered into actual combination with the copper, the melting-point of which will be very much higher.

A mixture of lead and tin, containing from one-fourth to one-half of the former, is sometimes used as a substitute for the pure metal, and is applied in the same manner as the foregoing. The alloy melts at a lower temperature than tin, and a less quantity will suffice to cover the surface of the copper, so that it has both practical and economical advantages; and it does not appear that, if used carefully, the lead will be dissolved out and enter into the food cooked in the vessel so as to be injurious to health. It may readily be distinguished by the dull surface it presents, similar to that of terne plates.

Another combination possesses some important advantages, though it is not quite so easy in its application. It is a compound of iron and tin, of which the former metal must not exceed about 12 per cent. A considerably higher temperature is required to melt this alloy, and it is therefore necessary to heat the vessel to a low red heat; while kept at this temperature the operator presses the end of an ingot of the alloy against the heated surface, and thus rubs it all over until it is sufficiently coated. When cool, any roughnesses are rubbed down so as to give it a good and smooth surface. This compound is very durable, and the articles so finished will stand a much greater heat than those coated with either the pure tin or the alloy with lead.

There is another application of tin, very different in its character from any of the preceding, which must now be referred to—the so-called silvering of glass for mirrors. The material commonly used for this purpose is actually an amalgam of tin and mercury. The plan adopted is to spread upon a flat table a sheet of tin-foil of rather larger dimensions than the piece of glass to be silvered, and then to brush some mercury over it as evenly as possible. When this has amalgamated with the tin some more mercury is poured upon it, and then the glass plate is slided edgewise over it, the edge of the glass dipping slightly under the surface. The object of bringing the two into contact in this way is to cause that part of the amalgam which has been exposed to the air, and which has therefore suffered some slight oxidation, to be pushed aside, so that none but the perfectly bright metal shall come into contact with the glass. The plate is then loaded with heavy weights, and inclined at a slight angle, by which means all the uncombined mercury is expressed and drains out. It is then stood on its edge until the amalgam has become dry and firm.

Tin-foil is made by the rolling and hammering out of tin, which can be carried to about $\frac{1}{1000}$th of an inch in thickness; and tinsel is produced by the coating of thin leaves of brass and other metallic compounds with a film of tin. Thin plates of tin are also often used for ornamental purposes, as they can easily be stamped with any device that may be desired; but as the pure metal is very soft, this application can only be employed where there is little risk of external force.

Tin is also employed by the manufacturer of coloured glass, of majolica, and other ornamental ware of that description, which need not be particularised here, as these uses have already been described in other series of articles. The student may be referred to Article XII. on "Colour," where the effect of opalescence in glass is described as being produced by the oxide of tin, and the opaque whites in majolica, and other enamelled stone wares, are stated to be due to the use of the same metal. In Article III. on the "Practical Application of the Fine Arts," the effects of the salts of tin in deadening the colours of glass are further detailed.

It will be readily inferred, from the description of the manifold uses of tin given in this and the preceding article, coupled with the fact of its very limited geographical distribution, that it is a source of no small wealth to the two counties which produce it. The statistics of the trade tend to show that the yield of tin scarcely keeps pace with the demand, and that as a consequence the value of the metal shows a tendency to rise. This has recently been the case to a very marked extent, as the supply of tin from Banca has, from some unexplained reason, fallen off; but that it is not a mere temporary fluctuation may be evidenced by going back a year or two, when prices were not equal to what they are now. For instance, in 1869, the black tin raised in Cornwall and Devonshire amounted to 14,725 tons, valued at £1,028,000, yielding 9,760 tons of metallic tin, valued at £1,201,450; exceeding the previous year by 460 tons of tin, and £200,000 in value. If we go back to the last century, the largest annual produce appears to have been 3,725 tons; and for the first thirty-eight years of the present century the greatest return was 5,290 tons. Since then it has been increasing (subject to minor fluctuations) to the above total. The annual value has been, during the same period, liable to very severe fluctuations. During the troublous times immediately preceding the final overthrow of the first Napoleon, the value per ton, as may reasonably be inferred, reached an unprecedented figure, the foreign tin at that time being practically excluded; but on the restoration of peace the price fell from £157 per ton, its maximum, to about two-thirds, and within a few years to about half that figure. There seems every prospect now that the demand will keep full pace with the supply.

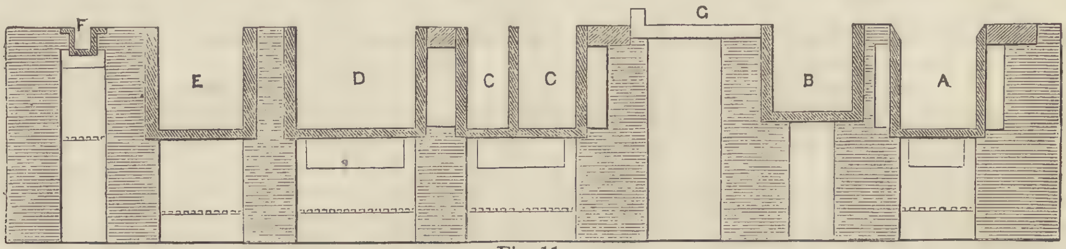


Fig. 11.

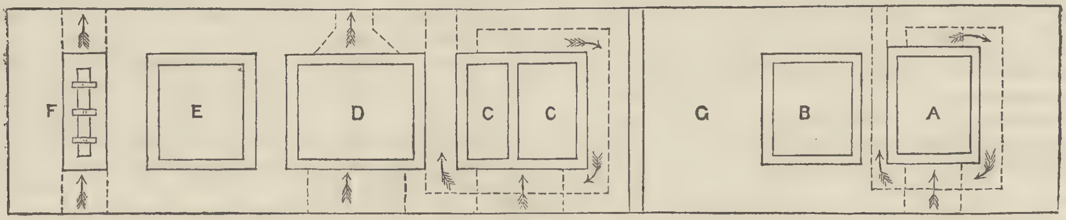


Fig. 12.

SILK CULTURE.—IV.

By Alexander Wallace, M.D.

PREPARATION FOR SPINNING—METHOD OF MAKING SILKWORM GUT—CHRYSALIS—EMERGENCE OF MOTH—RECEPTION AND PRESERVATION OF EGGS—QUALITIES OF COCOONS.

And now the critical period advances when the value of the crop, and the result of past labour will be determined. Up to this point all has been uncertainty. Thunderstorms, sudden changes of temperature, hot winds, insufficient ventilation, unhealthy food, or improper manipulation might so far have compromised in a very brief period the safety of the crop; but the cocoons once spun, the rest is a certainty, and the harvest secure. As, moreover, cocoons vary much in quality owing to the health of the worms, till they are gathered, the quantity and quality of the crop is a matter of speculation. The last few days, therefore, are anxious yet joyful ones, for the labour and toil, hitherto excessive, will after this diminish. In Japan a bed is prepared for the worm to spin in, consisting of rape or rice straw cut into short lengths and loosely spread on the tray; but in Europe the *manelli*, or bundles of heather or broom, asparagus-stalks, or seed-stalks of any of the cabbage tribe, etc. etc., are set up round three sides of the tray, while food is scattered very thinly about the tray. The "bushes" or "fagots"—as these bundles of heather, etc., are commonly called—should be longer than the space between the trays, and placed somewhat aslant, so that the worms may better crawl up, and that the liquid voided by them may not fall direct on those below. Each fagot may be fifteen inches apart from the next, so that a smaller fagot may be afterwards inserted between each. Dandolo advises that each fagot should touch the tray above, so that its branches curl over. I am doubtful about the propriety of this course—(1) because the worms will ascend from the lower tray to those above, which would not be well, unless they were all of the same age to a day; (2) because ventilation is almost entirely impeded by doing sc. The worms soon hasten to the *manelli* and crawl up, "mounting," then, seeking a convenient spot in the interstices of the stalks, commence their cocoons. It is a matter of importance to allow sufficient space for the worms, for if crowded, two or more will spin their cocoons together, which, being made of two threads, cannot be reeled (doubles), and are therefore of inferior value. One per cent. of doubles is the ordinary average in a good sample; five per cent. is the highest per-centage allowed in the sale of cocoons. Should the doubles exceed that percentage, less value is given for the lot. Some races, especially the bivoltine, average more doubles than other races. Worms may now be lifted up, when wandering away from the bushes, by the finger and thumb, without undue squeezing, and placed thereon. In thus removing worms, care should always be taken to take hold of the fore part of the body, and draw the worm upward and backwards; he is thus induced to loose his foothold—if drawn forward he will resist, and probably receive damage. The noise now in the silkworm-room is very perceptible, resembling a quiet rustling, partly caused by the worms spinning, partly by those moving about, partly by the action of the jaws of those still feeding. Temperature should now be kept even and steadily warm (about 70° to 75°), and ventilation well maintained. At this stage, if the worms are weak, some will die while spinning, and being concealed among the bushes, a very powerful odour, noxious to the living worms, will emanate. Any unhealthy or weakly worms should therefore be looked for and thrown away. After fastening the outside strands, by means of which the size of the cocoon is determined, the worm weaves first the outer loose envelope; but gradually contracting its movements, spins the tighter and closer body of the cocoon, and in twenty-four hours is hidden from sight. At about the third day the cocoon begins to

Fig. 5.—CATERPILLAR, COCOON, AND MOTH OF THE BOMBYX YAMA-MAI.

assume a hardness, and in a week is ready to be gathered. As the worm spins its cocoon from end to end in one thread, it is important not to disturb it during cocooning, lest the thread be broken. Good cocoons are those which have such a substance of silk that they resist pressure and feel hard to the touch, and at the same time preserve the shape and colour peculiar to their race. It is a very pretty sight to see the bushes well filled with white or golden cocoons.

Should any worms appear ripe for spinning, but unable or unwilling to rise, or should any fall to the ground while mounting, they should be removed to a separate frame, and a handful of seed-stalks or a few bushes of heather be laid down instead of set upright, upon or under which, in all probability, they will crawl and make a good cocoon.

But some worms, though fat, heavy, and generally very yellow, will not be induced to spin either on the high or low bushes. These should be collected every night and morning, and put into a basin of vinegar and water, for the purpose of making gut for fishing. After remaining in the basin for twelve hours they are thus treated:—

A board should be prepared 6 inches by 30 inches, with a row of pegs at each end, and notched all round the edges. Two intestinal tubes run through the silkworm, one on each side, of a clear transparent appearance; these are the silk receptacles, and should be separated from the head of the insect while in the vinegar and water, and the threads, one by one, drawn out rapidly to their full extent, and fixed at full stretch on the board by means of the pegs at one end and the notches which receive and fix the other end. This must be done quickly, as the air soon hardens and stiffens the string; they must on no account be passed through the finger and thumb, as they are of no value if flat; roundness, strength, and length are the points of value. The yellow mucilage which coats the strings is removed afterwards by being boiled in soap and water.

After the gut is drawn out the board should be placed in the sun to dry, and the old strings may be removed night and morning when new ones are put on the board.

To clean the gut, take a piece of soap the size of a nutmeg, and boil it in a gallon of water. When it is completely dissolved, put the gut into it and boil for ten minutes; take out and pass the gut through cotton-wool to remove what may be left of the yellow matter, but so lightly that the gut, which becomes soft by boiling, may not be flattened by pressure; when again stretched and dried on the board it becomes clear and strong.

Experience is necessary to do this well; but it is worth the trial with silkworms which would not spin, and would otherwise be lost—the more so as good silkworm-gut is really valuable, and I have been offered as much as four guineas per 1,000 pieces of the best gut. Silkworm-gut comes chiefly from Spain; its manufacture is well worth the attention of sericulturists at home and in the colonies.

After the cocoon is spun the caterpillar rests within the structure; having voided the contents of its intestinal canal and its silk, it contracts still further, throws off the skin, and becomes a chrysalis. The insect lies in this state about three weeks, and then emerges a moth. To get out of the cocoon, the moth splitting first the pupa-skin about the head and face, pushes these parts against the apex of the cocoon; the nose, being furnished with an alkaline secretion, is continuously applied. The alkaline fluid dissolves the gum and loosens the threads, and the moth pushing outwards separates these and emerges, leaving a small round hole in the cocoon, thus rendering it useless for reeling purposes. The moth, at first a feeble, soft thing, clings to the cocoon, if possible, in such a position that the wings may hang down over its back. These speedily enlarge, and after an hour or two are fully developed, and the moth is ready for the next stage, viz., wedded life. But prior to the moth emerging the hand of man interferes; for in order to preserve the silk for use it is necessary to reel the thread, and as this cannot be done after the cocoon is empty of the moth, it becomes necessary to secure the silk either by reeling the cocoon in the short interval which elapses between cocooning and the exit of the moth, which can only be done where there are few cocoons to reel; or by destroying the pupa inside by means of heat. This is effected in the East by exposing the cocoon for several days to the sun's rays, which are there sufficiently intense to dry up the life of the pupa. In Europe more commonly dry heat of an oven or of a steam-chest is employed. I found two hours' exposure in a baker's oven after the bread was drawn, at a temperature of about 170°, was sufficient to dry up the pupa thoroughly. This may easily be tested by cutting open a cocoon taken from the middle of the mass in the oven. When the pupa is reduced to a hard dry mass, easily reducible to powder, it is sufficient; but if still a moist mass, heat must be maintained for a longer time. Care must be taken that the cocoons be not burnt. Cocoons thus treated, and thoroughly dry, will keep for years without serious deterioration; may be pressed and packed into bales, and will travel round the world, and when placed in hot water will again spring into shape and reel well. When stripped from the bushes the cocoons should be denuded of the outer envelope of floss, which should be collected separately, having a value of its own for the manufacture of spun-silk. The cocoons thus denuded are sorted into those that are required for breeding purposes, which should always be chosen from the best shaped and stoutest cocoons, in order that, in accordance with the principle of selection, the progeny, following the example of their fathers, may produce superior cocoons. One-sixtieth part of the produce used to be retained for stock; but owing to the changes caused by the prevalence of the disease in Europe, very few cultivators rely now on their own "strain." The remainder are again sorted out into several classes for reeling purposes, and may be taken to market or sent to a filature (silk-reeling establishment). Eggs and dry cocoons may be transferred from one end of the globe to the other, but in no other stage will the *Bombyx mori* travel safely. Colonists are especially recommended thus to take advantage of the high prices of European markets, and send over their crops in one of these two ways. In order to obtain the best eggs, only those moths which are vigorous, well-formed, and free from blemish are allowed to copulate. The male may be distinguished by his elongated narrow abdomen, and by his tail, when expanded, being forked—or bifid; the female by her larger size, plump abdomen, and ovipositor, which is light-coloured and of a somewhat elongated pyriform shape. The moths emerge early in the morning, and are often found paired on the cocoons. Those coupled should be removed to a separate tray (the wings of the female being taken hold of), and allowed to remain undisturbed till the evening, when they should be separated, and the females placed on the paper or cloth intended for the eggs. In Japan the cards on which the eggs are laid are often placed in a frame of polished wood; the moths, disliking the polished surface, confine themselves to the card, and there deposit the eggs. It is a good plan to hang the cloth somewhat perpendicularly, and to tilt the upper portion of the cloth forward, so that any excretion from the moths may not fall upon the eggs already deposited. After separation from the male, and before the process of oviposition takes place, the act of defecation, or evacuation of a brownish coloured fluid takes place, or, as it is termed, the female clears herself. This act generally happens in the wild Bombycidæ, after the wings are dried. When the moth first begins to flutter about, and prior to copulation, the males are very ardent after the females, and if no females are at liberty, two or more males may be seen joined together. This act has also been observed in the Chinese species *Bombyx Pernyi*. As the moths emerge the empty cocoons should be removed. These are now only useful for the manufacture of spun-silk, and also as samples of the race, to be shown when the eggs are offered for sale, and to which samples the eggs should come true, *i.e.*, produce cocoons of like value. The egg when deposited is a flattened disc of a pale yellow tint, soon assuming a light brown tint, gradually changing into a dirty lilac grey. If the egg remains yellow or white, fecundation has not been effected. The eggs first laid are the largest, and produce the best worms; then the bulk of medium quality, the last eggs being smaller and of less vigour. Hence a careful educator will watch his moths during oviposition, and after the first twenty or thirty eggs have been laid (which he will retain for his own use) will remove the moth to another card or cloth, and after she has laid there about 100 eggs will throw her away, or retain the remainder of her produce on a separate cloth as inferior. Dandolo says that 22 square inches of cloth are sufficient to contain on the surface of the cloth 6 or 7 oz. of eggs. In placing the moths upon the cloths, begin at the top and go downwards. Eggs may be kept in an airy room. Each female will lay between 300 and 400 eggs.

As to the qualities of the cocoon.

There are nine different qualities. 1. *Bons cocons* (good cocoons), which have been brought to perfection. These are by no means always the hardest, but are compact, free from spots, and of a good shape.

2. *Cocons pointus* (pointed cocoons) have one extremity rising in a point. These, after affording a little silk in reeling, break or tear at the point, where the thread is weak, and they cannot be wound farther, as the fracture would occur as often as the thread reached the weak point.

3. *Cocons faibles* (weak cocoons) are rather larger than the regular cocoons, but do not contain more silk, their texture being less compact. These are separated from the other kinds, because in reeling they must be immersed in colder water, in order to avoid any furzing or entangling in the operation.

4. *Cocons doubles* (double cocoons). The threads of these are so mixed that frequent breakings occur in reeling, and often they cannot be reeled. In any parcel the proportion will reach from one to five per cent., which is the highest allowed without reduction in price.

5. *Cocons satinés, goufflons* (flossy cocoons). These are very imperfect cocoons, with a loose contexture, sometimes to such a degree that they are transparent. These cannot be reeled.

6. *Cocons ouverts* (perforated cocoons), as their name denotes, have a hole at the end, generally from the moth having escaped. They cannot be reeled in the ordinary method, as the thread always breaks when it arrives at the perforated place. Latterly, however, it being seen that the moth does not rupture the threads, but only separates and pushes them apart during the act of emerging, having previously liquefied the gum which bound the threads together by means of the alkaline fluid emitted from the face, attempts have been made to adapt machinery to their reeling, and silk has thus been produced.

7. *Chiques, cocons chiques*, are cocoons wherein the insects have died before perfecting their task. These are known by the adhesion of the worm to the cocoon, which prevents it rattling when shaken. The silk of these is as fine as of the first-mentioned quality, but not so strong nor so brilliant; and they must be wound separately, as they sometimes furze in reeling.

8. *Cocons tachés* are defective cocoons, spotted or rotten. They furnish foul bad silk, of a blackish colour.

9. *Dragées* (calcined cocoons) are those wherein the worms, after having completed their cells, are attacked by a peculiar disease which sometimes petrifies them, and at other times reduces them to a white powder—a fungoid disease known by the name of *muscardine*. In the former case they are called comfit cocoons, from the resemblance borne by the withered worm to a sugar-plum. The quality of the silk, so far from being injured by this means, is generally excellent, and it is even in greater quantity than in the cocoons of healthy worms. Comfit cocoons may be distinguished also by the peculiar light rattling sound of the dried worm within. They are much esteemed, and fetch a high price, but are not of frequent occurrence. 3 lb. of fresh or green cocoons will make 1 lb. of dried cocoons, and about 4 lb. of dried cocoons will produce 1 lb. of reeled silk; it therefore takes about 12 lb. of fresh cocoons to produce 1 lb. of silk.

BRICK AND TILE MAKING.—VI.

By Gilbert R. Redgrave.

BRICKS, TILES, AND TERRA-COTTA.

The manufacture of flooring-tiles has, we think, made greater progress during the present century than any other branch of the ceramic art; and this industry as now practised in Staffordshire, presents many features of great interest, and differs in many respects from the manufacture of the coarser wares we have noticed in our previous numbers. The old-fashioned 9-inch or 12-inch tiles made in wooden moulds in the same way as bricks are made, have now been almost entirely superseded by the thin machine-made tile, which has scarcely one point in common with its clumsy prototype. Tile-making, or at any rate the manufacture of encaustic tiles, is now a business entirely alienated from the brickmaker, requiring as it does a most costly plant and a totally different mode of procedure to the heavier clay goods. In some country places, however, oven tiles, floor tiles, and quarries, are still made and burnt along with the bricks. We need not devote much time to the consideration of the tiles made from brick earth, as the processes in every respect resemble those we have previously described. A carefully-prepared clay is made use of, and the tiles when partially dry, are smoothed over or trimmed with a steel instrument or knife, which gives them a silky, lustrous surface, and is supposed to make them more dense and durable. A tough clay is generally selected, such a clay, in fact, as would be employed for roofing-tiles; the tiles are generally either 6 inches, 9 inches, or 12 inches square, though 4-inch tiles are sometimes made from the dense Staffordshire and Shropshire clays. The chief fault of these common tiles, which are often used for paving the floors of cottages and outhouses, is their great porosity. They absorb so much water that they are always cold and damp to the feet.

This defect is not so apparent in the tiles made from the blue clays (*i.e.*, those clays which, owing to the presence of iron, burn blue), which are much more suitable for paving purposes, though very unpleasant in point of colour. In many parts of the country it is customary to use the blue bricks and quarries for foot pavements; but owing to their almost metallic surface, it is necessary to roughen them artificially to render them less slippery. Mr. Page, the engineer of Westminster Bridge, was so struck with the hardness and durability of the blue ware, that he employed 12-inch blue tiles for the foot pavements of the bridge; but they do not seem to have answered his expectations, as they have now worn away so much as to have lost every trace of their blue colour, and in some places have become very uneven. This is rendered all the more conspicuous by the occasional insertion of strips of granite, which stand out a quarter of an inch and more above the tiles.

Under the heading of flooring-tiles, we may also allude to the so-called Dutch clinkers, which are largely used for paving purposes. They are in reality a species of small, hard-burnt bricks, generally made from the gault or some similar clay, and employed for the interior of stables, for which, owing to their great hardness and imperviousness, they are admirably fitted.

Even so far back as the latter end of the thirteenth century, the art of making inlaid tiles or tiles which received their decoration from the insertion of a pattern in coloured clay, seems to have been practised in this country. The pavements of many old halls and churches appear to have been formed of such tiles, many of which evince great skill and care in their manufacture. The revival of the art of making these tiles—which seems to have been lost or to have fallen into abeyance—is due to an English manufacturer, Mr. Herbert Minton, of Stoke, whose name is now invariably associated with "encaustic" tiles.

Before going further we may explain briefly what we take to be the meaning of the term "encaustic." We understand such materials to be truly encaustic, as have the various colours they display actually intermixed with the substances or clays from which they are formed, and burnt in, as it were, at the same time as the article is fired: a combination, in fact, of coloured "bodies," as the clays in this state would be termed. Tiles formed thus by inserting for a considerable depth, or throughout their entire thickness variously-coloured clays disposed in certain definite forms would be true encaustic tiles.

In opposition to such tiles, we have what are known as "decorated tiles," or those which have on a plain surface, a pattern printed in one or more colours. These tiles have thus all the appearance of true encaustic tiles; but they have, of course, no such qualities of wear. They are therefore used for wall tiles, hearths, etc., and for places where there is no traffic. They are very commonly passed through the gloss-oven, where they receive an ordinary fritted glaze. In some of these pseudo-encaustic tiles, small bands of colour are printed round each of the edges, to represent the depth of the insertion of the coloured clays in the real tiles. A third description of tiles is known as majolica tiles, and here the clay receives a moulded or enriched surface in the biscuit state, and is then passed through the enamelling kiln and enriched with various opaque, glazed colours technically known as "enamel colours." These tiles, of course, are used solely for wall-tiling.

Having thus explained the various kinds of tiles, we may pass on to a more detailed account of the processes of their manufacture. The clay used for what we may call the foundation or body of an encaustic tile, has to be very carefully selected and prepared. We have already noticed in various other places, the manner of dealing with the clay in order to fit it for use, and in describing the mode of manipulating the clay for tile-making

in detail, we should have to repeat much of what has been said previously. The principal seat of the tile manufacture is, of course, in the vicinity of the Staffordshire potteries, and the clay mostly used is the red surface clay of the district, and the buff-coloured clay or marl. For those tiles which are required to be of a pure white colour, or which it is proposed to stain of a delicate tint, it becomes necessary to use the more expensive white clays of Dorsetshire and Devonshire.

The clays undergo almost the same nicety of preparation for tile-making as would be observed in the case of pottery. The raw clay is first subjected to the action of the blunging mill, which consists of a set of long cutting-knives like the teeth of a gigantic rake. These knives are inserted into a horizontal shaft, which is caused to revolve slowly in a pan or tank about half full of water. The action of these knives is to tear and beat the clay to pieces, and to mix it with the water to the consistency of a thinnish cream. This cream, technically known as "slip," runs away by natural overflow to the evaporating pans or "slip kilns," and the heavier and more solid impurities in the clay sink to the bottom of the blunging mill, whence they may be from time to time withdrawn. In the condition of slip, any mixture of clays or introduction of colouring matter can be admirably and thoroughly effected. For some processes in the manufacture of encaustic tiles, as we shall see later, the clay is used either as slip or in a butter-like state; but for the ordinary pressed tiles it is used slightly damp as a powder.

The slip-kiln, till recently in common use for drying or evaporating the water from the clay, consists of a number of parallel, horizontal flues, covered with fire-clay quarries, and having a furnace at one end, and a lofty chimney at the other, in order to promote a sufficient draught. The floor of the slip-kiln is surrounded with a brick margin, raised about twelve inches above it, and is laid at such an incline that, while at the end nearest the furnace where the heat, of course, is greatest, the liquid slip when first run on is about 7 or 8 inches in depth; at the far end near the chimney the depth is not more than from 2 to 3 inches. It is found by this means that the whole of the clay is ready to take off about the same time. Slip-kiln builders have several fanciful regulations about the size of their flues, which they decrease very rapidly at the end of the kiln furthest from the furnace, deeming that in this way they produce a sharper draught into the chimney, the only actual result being that the flues very soon get filled up, owing to their shallowness, with the leakages through the joints of the cover-quarries. The time required to evaporate a charge of slip on an ordinary-sized kiln is from seventeen to twenty hours, and the clay is considered ready when it is all in a soft putty-like condition. A long slip-kiln requires careful management, as the clay is very liable to become partially caked and unfit for use, owing to its being overdried at one end before the other is ready.

Slip-kilns will, however, soon be entirely superseded by the patent clay presses or wringing machines, introduced by Messrs. Needham and Kite. By means of this invention the liquid clay is run into a number of linen cloths folded into a series of bags, and inserted between fluted boards placed in a frame. These boards are gradually driven together by hydraulic pressure, and the water in the clay is expelled through the pores of the linen wrappers; thus in a very short time the clay is dry enough for use, and when prepared in this way it is said to be better than that which has been boiled. Were it not for a heavy royalty now charged under the patent, and the great wear and tear in the cloths, this process would doubtless be universally employed by potters. For the manufacture of the clay-dust, however, the wringers alone are insufficient, as the whole of the water must be expelled by means of kiln-drying, before the clay can be ground. The dried clay is pulverised under horizontal stones, and if necessary dressed through a fine sieve.

The almost impalpable powder obtained in this way is now ready for use. As it comes from the mill it is not quite damp enough to bind, and in order to moisten it equably and sufficiently, a curious process is now adopted. It was found that no system of sprinkling with water or other artificial mode of wetting it rendered it all equally damp. Advantage has therefore been taken of the sponge-like action of plaster of Paris. Large beds, some four or five inches in thickness, of this material are prepared and carefully wetted; on these beds an even layer of clay-dust is spread previous to its use, and this clay sucks up from the damp plaster exactly the proper amount of water to give it the required cohesion. From these beds, the clay is carried to the presses, which are cumbrous affairs, made much after the fashion of coining presses, having a screw to which is attached the lid of the mould and heavy arms to cause the revolution of the screw. The mould itself, made of course of metal, is formed by a depression in the otherwise level surface of the table on which rests the clay. The workman begins by scraping across into the mould enough of the powder to fill it, and roughly levels the surface by striking it with a straight-edge. The screw or die is then brought down gently at first to expel the air, after which a sharp and heavy blow is given by rapidly swinging round the arms of the screw. By this second blow the clay in the mould is reduced to about two-thirds of its former thickness, and is so far consolidated that it can readily be moved about and handled. The mould is relieved by an upward motion of the plate forming the bottom of it, worked by a lever-handle at the side of the press. On bringing this plate back to its former position, the mould is again ready to charge with clay for the formation of another tile; the entire process occupying far less time than we have taken to describe it. For small tiles and diagonals or angle-tiles, a divided mould making two at a time is commonly employed. A press on a very much smaller scale and worked by girls is used for making in exactly a similar way, the encaustic tesseræ for mosaic work.

Of course, by using dust stained in various colours, while the clay is in the state of slip, tiles or tesseræ of any self tint can be obtained by this process, and tiles made of pure white clay-dust are in general use for decoration, either by transfer printing or painting. Before the tiles can be decorated, they must necessarily be burned into the state of biscuit, which is effected in "ovens" of the kind commonly used for burning pottery. These ovens may be described in a few words, as follows:—Round a circular chamber which may be from 14 to 16 feet in diameter, are arranged a series of fire-places or "fire-holes," varying from eight to twelve in number. These fire-holes communicate with the oven by means of flues passing under the floor to an orifice in the centre, and small vertical chimneys built against the inner wall called the "bags." These ovens may be from 14 to 20 feet in height, and are covered in at the top with a brick dome pierced with openings (generally three to each fire-hole) to carry off the products of combustion. A fierce upward draught is produced by surrounding the entire oven with a flask-shaped chimney. This chimney, from the fact that its width at the base is such as to enable the workmen to attend to the fires under cover, is called the "hovel." The goods to be fired are enclosed in oval boxes of fire-clay called "seggars," to protect them from the flames which freely enter the oven through the floor and bags. Some tile-makers have introduced seggars of a square form which can be better filled with tiles than the round or oval boxes, but are said not to last so long. These seggars when filled are placed one above the other in stacks, sometimes twenty-five seggars in height, called "bungs." In firing a biscuit oven, the usual precautions are taken to raise the heat very slowly, so that the goods are "smoked" for many hours before the full firing, which lasts about forty-eight hours, is commenced. All tiles have to be first fired in the biscuit oven, and for plain encaustic tiles, this is the only firing required.

SHIP-BUILDING.—VIII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF IRON SHIPS (*continued*).

It will be remembered that in remarking on the framing of wood ships considerable importance was attached to the use of diagonal riders; and in the earlier days of iron ship-building many proposals were made to employ similar strengthenings in iron ships upon the inside of the frames. These proposals were based upon an entire misconception of the relative capabilities for resisting strains of the skins of the two classes of ships, and they have never found much favour with practical builders. The planking of a wood ship is made up of numerous narrow strakes, almost destitute of edge-connections, and very liable

on that account to sliding of edge on edge when any change in the longitudinal form takes place; consequently, diagonal ties are in them most important auxiliaries. The plating of an iron ship, on the contrary, is made up of comparatively broad strakes, strongly riveted to each other at the edges, and forming a combination which is capable of resisting and transmitting strains in all directions, without any aid from diagonal ties. In other words, the edge-riveting of the strakes of outside plating in an iron ship does in a much more efficient way that which the diagonal riders are intended to do in a wood ship—viz., to prevent changes in the relative positions of the various strakes in the skin, and to increase the rigidity and strength of the structure.

Reverting to our comparison of ships to girders, we may contrast the conditions of wood and iron ships more readily, and further illustrate the statement just made. In the wood ship's girder, for the upright position, the web, between the upper and lower flanges, would be formed of the planking on the sides, as we have said, of narrow strakes imperfectly connected to each other. When subjected to strains, such a girder might obviously bend without developing the full strength which it would have if the web, instead of being made up of several layers badly joined, were formed in one piece; for in the latter case the web would greatly aid the flanges, whereas in the former the flanges would have to act almost alone, and the layers in the web, instead of acting together, would probably slide upon one another. Any means, therefore, of increasing the *rigidity* of the web, must lead also to a gain in the strength of the girder; and in preventing the sliding of layers in the web, diagonal braces strongly fastened to the various layers would be of great service. The transverse frames, as was previously explained, are not capable of opposing this change of form, and consequently diagonal riders must be used in wood ships. Nor can the transverse frames of iron ships oppose similar changes of form; but in them the strakes of outside plating are so strongly riveted to each other at the edges as to form what is almost equivalent to a web made of one piece, and possessing such an amount of rigidity as to enable the flanges to develop their strength satisfactorily. No one would propose to add diagonal strengthenings to the web of a girder if that web were made up of one piece; and similarly it would be most unwise to dispose material in the form of diagonal riders in an iron ship, seeing that the skin-plating really constitutes one well-connected mass. These remarks are made here rather than in our farther description of the skins of iron and wood ships, because the use of diagonal strengthenings is so closely connected with the arrangements of the framing.

Attention will next be directed to the "diagonal system" of framing iron ships. This has not been commonly adopted, but it has been made use of in the construction of several vessels, and therefore merits notice.

The frames used in this system consist of frame angle-irons, reversed frames, and floor-plates, just as the ordinary transverse frames (shown in Fig. 20, page 150) are formed. Instead of being placed in vertical transverse planes, however, the frames are inclined to the vertical at an angle of about 45 degrees, and consequently would appear in a profile view of the ship so built, just as the diagonal riders of a wood ship appear in the elevation, Fig. 15, page 81. In some vessels built on this plan the frames on one side slope forward throughout the length, and those on the other side slope aft. The deck-beams, also, instead of being placed transversely, are arranged diagonally, those belonging to the different decks being made to cross one another, and in many other minor respects common arrangements are departed from. As a consequence of the diagonal positions occupied by the framing, it is found advantageous to make the butts of the outside plating also diagonal, or parallel to the frames, and in every way it is attempted to substitute diagonal for transverse or vertical lines of weakness.

The aim of all these departures from ordinary methods is obvious. Under the action of longitudinal bending strains, an ordinary iron ship is more likely to fail at a transverse section passing through a line of rivet-holes in wake of one of the frames, than at any other section. The originators of the diagonal system, starting from this fact, have aimed at so disposing the material used for stiffening the skin, as to make it impossible for a ship to break across at any transverse section of the outside plating, without also breaking across the frames, beams, etc., which cross the line of fracture of the plating. In other words, they have sought to remedy the great defect of the transverse system of framing already pointed out—viz., the inefficiency of the main frames against the principal bending strains to which the ship is subjected. And to some extent they have succeeded. For example, the lines of riveting of the plating to the frames are no longer in transverse planes, but in diagonal lines, and therefore less likely to be followed by the fracture. Presuming, as seems probable, that the line of fracture will be more or less closely in a transverse plane, it will be evident that several of the diagonal frames will cross that line, and lend their strength to the plating, requiring to be broken across before the entire separation of the parts before and abaft could be effected. The same idea, doubtless, has led to the beams being placed diagonally, but the gain of strength which follows is much less important.

Against these advantages must be set some grave disadvantages. First of all, the diagonal system leads to much more complicated and costly workmanship than is required by the transverse system. It appears also that, although the diagonal framing does lend some aid against longitudinal strains, there still remains a necessity for employing internal keelsons and stringers similar to those used in ordinary iron ships. Diagonal frames, moreover, have this disadvantage as compared with transverse vertical frames, that they are heavier and necessarily tend to droop at the upper extremities, being retained in their inclined positions only by the support of the outside plating. For these and other reasons ship-builders have never favoured the use of this system, but have preferred to employ the transverse system, which can be so reinforced by longitudinal strengthenings as to answer well in even the largest merchant ships. In fact, with equal weights of material it appears possible to give a vessel almost, if not quite as great strength against longitudinal strains by framing her transversely and putting in good keelsons and stringers, as by framing her diagonally. Even with diagonal frames longitudinal strengthenings would be used, and the saving in weight obtained by using transverse instead of diagonal frames would aid in giving increased longitudinal strength to the vessel built on the ordinary plan. Apart from this, however, there are the important considerations of cost and simplicity of construction, both of which are greatly in favour of the transverse system, and these have, no doubt, been the chief causes of the non-employment of the diagonal system.

Turning next to the longitudinal system of framing, we meet with an arrangement which well combines simplicity and strength, and is likely to be more extensively used when the necessity for following out in practice the true principles of construction becomes more pressing. At present the transverse system of framing can be made to answer even in our largest merchant ships; but it has the great defect of leaving to supplementary strengthenings the work of succouring the outside plating against longitudinal strains, while the greater portion of the weight of material used to stiffen the skin is available only against transverse strains. In the longitudinal system the conditions are entirely reversed. The main frames are effective against longitudinal strains and are all directly connected with the plating they are intended to assist, while the transverse framing is made to occupy a subordinate position. Such a change could not be expected to find favour at once, involving as it did a departure from long-used methods, and even now the longitudinal system is but seldom used by private ship-builders. It has been used, however, by its author, Mr. Scott Russell, in several of his ships; the *Great Eastern* is so constructed; and the system of construction used in the armoured ships of the

Fig 22.

Royal Navy is in some respects an outgrowth from the longitudinal system. Facts such as these are, we think, sufficient testimony to the merits of this plan of building, which without further preface we will attempt to describe.

In Fig. 22 is shown a transverse section of a portion of the framing of a longitudinally-built ship. It will be seen that there is no external keel, but what has been described as a "flat-

plate" keel; upon which stands a vertical keelson, or keel (K), formed of a plate with double angle-irons on both edges. This keelson would be continuous throughout the length of the ship, the butts of the several lengths of plate and angle-iron used in its construction being carefully shifted from those of the flat-keel plate, and secured by well-riveted straps. Each of the strakes of plating is supported by a longitudinal frame or girder (L) formed of a plate with a single angle-iron on each edge. These plates would, of course, be varied in depth and thickness according to the size of the vessel, as would also the dimensions of the angle-irons. The butts of the plates and angle-irons would also be carefully shifted and strapped; and in the former operation regard would be had not merely to the butts of the particular girder or frame, and the strake of plating to which it was secured, but also to those of the other longitudinals, in order to avoid any specially weak cross-section. The longitudinals stand square to the plating at every section, so that the angle-irons on their edges are not bevelled; and as a consequence the surface of the plates is "twisted." The greater number of these frames would be continued right forward to the bow, and to within a short distance of the stern of the ship; but some of them would be stopped short at sections more or less distant from the extremities where the girth of the vessel becomes much less than it was amidships. At the stern, transverse framing is often employed for a small part of the length, as there are special advantages gained by this arrangement in portions where the vessel is very fine; in some cases, however, the longitudinals extend quite to the stern-post.

Only a portion of the vessel's section is shown in Fig. 22, but it illustrates the great features of the arrangements that would be made at least up to the height of the lower deck. Slight variations, of course, would occur in different vessels. For example, a builder might not fit a longitudinal frame on every strake of plating, but on only every other strake; and in the *Great Eastern* herself only the strakes near the middle line, which have to bear the strains consequent on the ship taking the ground, are thus individually supported, the longitudinals coming on alternate strakes at other parts. The parts of ships lying above the lower decks are not usually framed longitudinally, sufficient strength being obtained from plating laid on the deck-beams, as we shall endeavour to explain fully hereafter.

The simplicity and efficiency of this system cannot fail to be remarked. It provides ample longitudinal strength by means of the strong girders directly connected with the outside plating, and crossing the probable lines of fracture at right angles. In an earlier paper it was remarked that by placing two thin plates of iron at right angles to each other, and securing them in that position by connecting angle-irons, it was possible to form a strong T-shaped girder out of plates which apart could not sustain their own weight without bending between the points of support. Here we have this simple principle practically applied. The thin bottom plating, which would bend or buckle readily if unsupported, is effectually stiffened by the longitudinal frame, also formed of a thin plate with angle-irons attached. When a ship is subject to hogging strains, the lower part is brought under compression, and if there are intervals of comparatively unsupported plating, as there would be in a transversely-framed ship without numerous longitudinal strengthenings, the plating will be very liable to fail, not by direct compression, but by *bending* or *buckling* between the frames. The thinner the bottom plating is made, the greater is the danger of buckling, and the more need is there for efficient longitudinal stiffeners; but no fear need be entertained on this account, even with the thinnest plating, so long as such a system of framing as is shown in Fig. 22 is employed.

This matter has an important bearing on the probable future use of steel in ship-building. Steel has not, as yet, been largely used, but there is every reason to anticipate its more general employment when its manufacture has been somewhat improved. At present ship-builders feel some distrust in using it, because it is not of so certainly uniform a quality as might be wished; but when this objection is removed, as it doubtless will be, the obvious gain by using the stronger material in place of iron will probably lead to its extensive employment. Good iron plates will bear a tensile strain of from 20 to 22 tons per square inch of sectional area, whereas steel plates of good quality, as now made, will bear a strain of more than 30 tons to the inch, so that being half as strong again as the iron, the steel plating of a ship need only be two-thirds as thick, or as heavy, in order to give the same strength against tensile strains. Against compressive strains tending to buckle the bottom plating, the thinner steel plating would need longitudinal stiffening even more than the iron plating, and it may be reasonably anticipated, therefore, that when steel ships become more common, the longitudinal system of framing, or some modifications thereof, will come into more general use. It may be interesting to add that professional ship-builders who have inspected the steel blockade-runners built in this country during the Civil War in America, have reported that it was a common thing to see the bottom plating slightly bent, or buckled, between the transverse frames—a fact which entirely bears out the opinion expressed above.

Provision being made for the longitudinal strength by the arrangements shown in section in Fig. 22, other means are required to give the necessary transverse strength. These are of a very simple character, and need but a brief description. Mr. Scott Russell relies largely upon the transverse bulkheads to supply transverse strength, and fits as many of them as the service for which the ship is intended will permit. His rule, where the plan can be followed, is to have the ship subdivided into compartments of which the length is not greater than the vessel's extreme breadth, but this cannot always be done. The bulkheads, being formed of plates well stiffened by angle-irons, constitute almost rigid partitions in the hold, and the strength thus obtained is transmitted to the parts lying between them by means of the longitudinal frames. In some cases, and we believe the *Great Eastern* herself is an example in point, the bulkheads are almost entirely relied upon to supply transverse strength to the structure; but in other cases, where the bulkheads are comparatively far apart, transverse framing of a special character is fitted in the intermediate spaces. These transverse frames—or, as Mr. Russell terms them, "partial bulkheads"—are usually about 12 or 14 feet apart; and made up of short pieces of plate, fitted between the continuous longitudinals (L, L, L, L), and connected with them by pieces of angle-iron. The outer edges of these plates are connected with the bottom plating, and on their inner edges there is a single reversed angle-iron, worked like the plates in short lengths.

In the *Great Eastern* a water-tight iron skin is fitted upon the inside as well as the outside of the longitudinal frames, and so a "double bottom" of a cellular construction is formed. The advantages in point of safety gained by this arrangement have been already illustrated, and the importance of thus constructing iron ships has been urged. Double bottoms also add greatly to the strength of the lower portions of iron ships; for experimental researches made in connection with the design of the tubular bridges over the river Conway and the Menai Straits, showed conclusively that with wrought iron the cellular construction was best adapted for resisting compressive strains. The cost of construction is, of course, increased by having double bottoms, and there is a decrease in the internal space available for stowing cargo; but it seems a questionable policy to set these disadvantages above the advantages just referred to, especially as they may be associated with a moderate total weight of hull, after including the material in the second skin.

The principal objections urged against the longitudinal system by the advocates of the transverse system, are the greater cost of construction it entails, and the fact that it leaves considerable spaces of the bottom plating without direct support against local strains. Taking the latter objection first, it must be admitted that there is some force in it, although its importance may have been over-estimated. In a ship such as that illustrated by Fig. 22, for example, it would be possible to find spaces where the bottom for a length of 12 or 15 feet and a breadth of 3 or 4 feet would have no direct support, being framed in, as it were, by the longitudinals and the partial bulkheads; and where no partial bulkheads are fitted these unsupported spaces would, of course, be much longer, although not broader. Local strains, such as follow upon grounding or striking some fixed hard body, would be most injurious in their action on these unsupported spaces, and on this account the introduction of more closely-spaced light transverse framing seems desirable. It will be shown hereafter that in building the iron-clads of the navy this

is actually done, and with a small expenditure of material the bottom plating is well supported.

The remaining objection, additional cost of construction, is no doubt a true one at present, because of the fact that nearly all iron ships are transversely framed. Greater acquaintance with the longitudinal system would, however, undoubtedly reduce the cost of building very considerably, and make it compare more favourably with the transverse system. One thing is certain, that the necessary strength can be given to an iron ship with a less expenditure of material when she is built on the longitudinal system than can be done when she is framed transversely; and this saving in weight, adding as it does to the vessel's cargo-carrying power, must make her future service more remunerative. Continuing at work for twenty or thirty years, and having during all that time the power of carrying, on the same draught, say 100 tons of dead weight more than if she were built on the old plan, a ship longitudinally framed may in the end prove the cheaper, although her first cost may be greater. From the commercial as well as the structural aspect of the case it appears desirable, therefore, that improved methods of construction should be more generally adopted.

SEATS OF INDUSTRY.—XXIII.

PHILADELPHIA (*continued*).

BY WILLIAM WATT WEBSTER.

At Girard College, already mentioned, 340 boys are supported and educated on a foundation estimated at 8,000,000 dollars. This magnificent institution, unequalled in the United States, was endowed by a Philadelphia merchant named Stephen Girard, who did much to promote the commercial prosperity of the city. By his will this worthy forbade the appointment of any ecclesiastic, missionary, or minister, to any office in connection with the college, and even ordered them to be refused admittance within its precincts. Another part of his deed, however, directed that care should be taken "to instil into the minds of the scholars the purest principles of morality," and from this it has been inferred that Girard did not intend to exclude the Bible from the curriculum of instruction, and the directors have considered themselves justified, under this clause, in binding the president to have family worship morning and evening, and to perform regular religious services twice every Sunday, either personally or by some competent lay deputy. There are three medical colleges in Philadelphia, with an aggregate annual attendance of about 1,500 students. The university at Philadelphia, founded in 1755, occupies a large building originally built for the President of the United States, and is chiefly distinguished as a medical school, but in addition to its faculty of medicine, it has faculties of arts, natural science, and law, and it has also attached to it a junior academy and a charity school. It possesses valuable philosophical apparatus, and a considerable library. The oldest seminary in Philadelphia was incorporated by William Penn under the title of the Friends' Public Schools. It is a wealthy institution, and supports a number of schools which give instruction in Greek and Latin, mathematics, and natural and mental philosophy. The astronomical observatory of the city belongs to this institution, and it also possesses valuable philosophical apparatus. In addition to the educational establishments already noticed, there is in operation in the city and county of Philadelphia, a comprehensive and highly efficient organisation for imparting education to the people under the administration of a school-board. This system includes a high-school, where ancient and modern languages, mathematics, mental, moral, natural, and political science, drawing, etc., are taught by a principal and ten professors; and grammar, secondary, and primary schools. The average annual attendance at these schools is estimated at about 50,000, and the expense at about £40,000. There are some 400 female and 100 male teachers employed in the schools. Among the principal libraries and literary and scientific institutions in the city, are the Philadelphia Library, established by Franklin in 1731, which occupies an elegant marble edifice, and possesses considerably more than 70,000 volumes, a museum and philosophical apparatus; the American Philosophical Society, established in 1769, which has a library of about 22,000 volumes, and a valuable museum, and which has published several volumes of Transactions; the Academy of Natural Sciences, comprising a library of about 13,000 volumes, and a cabinet of natural history, believed to be the most complete in America, and particularly rich in birds, of which there are some 25,000 specimens; the Athenæum, incorporated in 1815, which occupies a fine building in the Italian style, and has a library of upwards of 10,000 volumes, and a reading-room, where the principal European and American newspapers and a large selection of European and American magazines are to be found; the Pennsylvania Historical Society; the Franklin Institute, for the promotion of the mechanical arts, and an Academy of the Fine Arts with a gallery of 1,000 pictures. Of the numerous charities the most noteworthy are the almshouses on the banks of the Schuylkill, consisting of four distinct ranges of buildings containing nearly 4,000 rooms; the Pennsylvania Hospital, established in 1752, one of the finest institutions of the kind in the United States, attached to which are a valuable anatomical museum, a library, and a handsome building erected in 1817 for the accommodation of Benjamin West's picture of "Christ healing the sick," the exhibition of which is a highly profitable source of income to the hospital; and the United States Marine Hospital, for the maintenance of invalid officers and sailors of the navy, besides various liberal and extensive institutions for the deaf and dumb, the blind, fallen women, orphans, etc. The Volunteer Fire Department of the city is 3,000 strong. Besides twelve banks of issue, there are fifteen savings banks in Philadelphia, and an extraordinary number of benefit societies. The hotels of Philadelphia are very extensive establishments. It is doubtful whether any American metropolitan city contains a larger or more beautiful hotel than the "Continental," which covers an area of 41,536 square feet, comprises a main hall 185 feet in depth, contains over 100 complete suites of family rooms, and requires 280 servants in various capacities. There are six excellent markets in the city, and the streets are traversed by tramways in all directions, the number of cars amounting to about 500, drawn by about 3,000 horses. The city is divided for municipal purposes into twenty-four wards, and is governed by a mayor, twenty-four select council-men, and ninety-five common council-men. Philadelphia sends seven representatives and two senators to the State Legislature.

The commerce of Philadelphia is very extensive and has been rapidly increasing. In the rivers Schuylkill and Delaware it possesses the advantage of a double port; the former, being the shallower, is set apart for the domestic or internal trade, and is the grand depôt for the coal and petroleum of the Union; and the latter, having water to float the largest merchantmen close to the quays, is exclusively resorted to by vessels engaged in foreign trade. To show the vast and rapid increase in the coal trade of Philadelphia, it may be stated that in 1825 only 5,306 tons were brought to the city by the Schuylkill, whereas thirty years later the quantity of coal sent down by the same channel amounted to about 3,000,000 tons, exclusive of twice as much supplied through other routes. A large quantity of this coal is exported from Philadelphia to other ports in the United States. The exports of petroleum from Philadelphia have made extraordinary progress. In 1863 there were shipped at the port but 4,930,708 gallons, valued at 1,382,082 dollars, and in 1867 the quantity had increased to 28,751,445 gallons, valued at 8,053,233 dollars. Besides coal, petroleum, and iron, the principal articles exported from Philadelphia are wheat and wheaten flour, Indian corn, and other agricultural products. The imports consist principally of cotton, woollen, and silk goods; sugar, coffee, and tea; iron and hardware; wines, brandies, spices, dye-stuffs, etc. Philadelphia ranks fourth among the ports in the United States in point of shipping, being inferior only to New York, Boston, and New Orleans. In 1865, 531 vessels with an aggregate burden of 159,579 tons entered the port. The foreign trade is small compared with the home or coasting trade. In 1866 the exports were valued at 17,913,901 dollars, and the imports at 14,115,004, being several millions of dollars in both cases less than they were valued at ten years previously. Philadelphia is fast becoming an important manufacturing as well as commercial city, the annual value of its manufactures being now upwards of 175,000,000 dollars. This city has gained a reputation in America for its shot, nail, cotton, paper, rope and glass manufactories, and it is the largest publishing emporium in the United States. Besides large quantities of books, there are printed in Philadelphia 13 daily, 4 tri-weekly, and 46 weekly newspapers; 44 magazines and periodicals, 30 of which are weekly; and 2 daily and 3 weekly papers in German.

TECHNICAL DRAWING.—LX.

GOTHIC STONEWORK.

PERPENDICULAR ENGLISH PIERS

Are sometimes simple octagons in plan, as in the preceding styles, but these are not so frequent as before. Clustered piers occur very often, their general form being that of a square set diagonally. An example of these is given in Fig. 495, p. 113, in order that it may be compared with those of the two preceding styles.

PERPENDICULAR ENGLISH CAPITALS AND FOLIAGE.

The capitals are either circular or octagonal, but the necking is usually the former, and the upper members of the abacus almost invariably of the latter form. The bell portion is mostly plain, but is often enriched with foliage of an exceedingly conventional character. It is shallow and formal—without either the freedom and boldness of the Early English, or the natural grace of the Decorated period, and with a certain squareness of outline which the eye soon detects.

We frequently find the tendrils, leaves, and fruit of the vine carved or sculptured in great profusion in the hollow of rich cornice mouldings. The example (Fig. 519) here presented will illustrate this. It is taken from the west doorway of Beverley Church, Yorkshire. The base mouldings are usually set upon a lofty polygonal plinth, which is sometimes double, the lower one projecting, and the projection moulded with a hollow or reversed ogee. In clustered piers the bases are mostly treated separately, as is the case with the capitals; but sometimes the mouldings are continued all round, as are also the plinths.

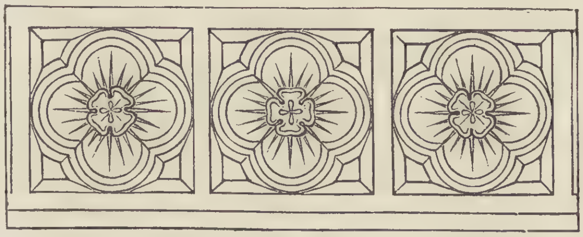


Fig. 513.

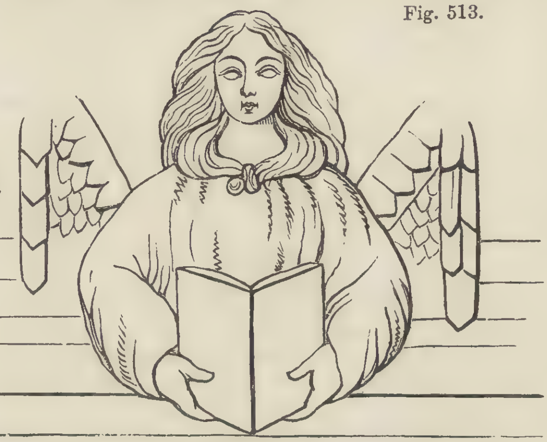
Fig. 515.



Fig. 514.


Fig. 518.

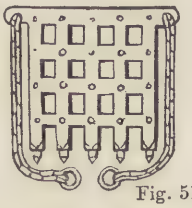


Fig. 516.

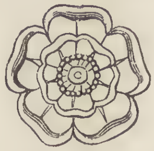


Fig. 517.

PERPENDICULAR ENGLISH ORNAMENTS.

One of the most distinguishing features in the system of ornamentation of this period is that called "panel-tracery" (Fig. 513), with which the walls and vaulted ceilings of buildings are almost entirely covered. The patterns were formed by mullions and tracery resembling windows, and a variety of other panels of different forms, such as circles, squares, quatrefoils, etc., are profusely used in subordinate parts, which are enriched with tracery, featherings, foliage, shields, etc., disposed in various ways. A very rich description of vaulting was also frequently used, composed of pendant curved semicones, covered with foliated panel-work, called "fan-tracery," from the design resembling a fan spread open.

Another very general ornament of this period is the Tudor flower (Fig. 514). This ornament is formed of a series of flat leaves, placed upright on the stalk. It was very much used late in the period, in long suits as a crest or ornamental finishing, on cornices, or in forming a beautiful enriched battlement. The examples differ considerably in detail, but the general effect is nearly the same in all.

Cornices and brackets were frequently ornamented by angels' heads, with shoulders, wings, and arms. These are called **Angel-brackets, and Angel-corbels.**

A great number of edifices (says Rickman) of this style appear to have been executed in the reign of Henry VII., as the angels so profusely introduced into his own works are abundantly scattered in buildings of this style. Fig. 515 is part of an angel string-course from St. Mary's Church, Oxford.

The Portcullis (Fig. 516) and Rose (Fig. 517)—both badges of the Tudors—were constantly carved as ornaments.

The crockets (Fig. 518) belonging to this style for the most part partake of the squareness which pervades all the foliage, and in a few instances animals and figures were used for this purpose.

The buttresses are, as far as the plain ones are concerned, similar to those of the preceding style, but are sometimes finished with a crocketed pinnacle. In richer examples the faces are covered with panel-work, and are finished with square pinnacles sometimes set diagonally and terminated with a crocketed spire, or finished with an animal or such-like ornament.

Parapets with square embattlements are very common at this period, but they are also frequently panelled or pierced with tracery in quatrefoils, or trefoils inserted in square, circular, or triangular compartments. The cornice is often composed of several mouldings, divided by rather shallow hollows, in some of which flowers of square form are placed at intervals, and in others figures or grotesque animals (as at Mold Church, Flintshire) are introduced.

The towers are frequently on a grand scale, and are often devoid of spires, though frequently surmounted by a lantern, and sometimes by four little turrets placed at the angles. The towers of some of the churches of this period are in some cases almost entirely covered with panel-work, as that at Wrexham, Denbighshire. Towers of this period are very numerous; amongst the best are those of Canterbury, York, and Gloucester Cathedrals, and the churches at Boston and Louth in Lincolnshire; Kettering, Northamptonshire; Cirencester, Gloucestershire; Great Malvern, Worcestershire; Magdalen College, Oxford; St. John's, Chester, etc.

The gradual decline of the Gothic style is very evident in the later churches of this period, especially in those of the beginning of the sixteenth century. It will be easily understood that the Reformation was for a time a bar to the revival of this style and the introduction at the same period of classical architecture, called the Renaissance, whilst the elements of the Gothic, though much degraded, were still in existence, led to that mixture of features, and that incongruity of style which followed, and which has been called the Debased Gothic, in which every real principle of art and of beauty was lost. It may be known by its general heaviness of design and want of elegance in detail—depressed archways and square-headed windows with perpendicular mullions, the heads of the lights often without foliation. It is chiefly found in repairs and alterations made between 1540 and 1640; but some few specimens of good work, especially of fan-tracery, are to be found. In Italy the Gothic was at once superseded by the Classical; but in other countries

it waned into forms which have been termed "After-Gothic," which gradually merged into the Revived Classic. Within recent years a revival of the Gothic has taken place in this country, and buildings have been, and are being, erected, which will well bear comparison with those of the Middle Ages. We have architects too, who, in their knowledge of scientific principles of design and construction, and their enthusiasm in their vocation, have never been surpassed in any country or period; and, further, we have mechanical appliances for working stone and iron, and for building purposes generally, never equalled—but *we want educated workmen.* In the Middle Ages, architects, as distinct practitioners, were scarcely known, and little more than the general arrangements of a building were designed by them. The rest lay with the workmen, who, working in bodies, largely influenced the beauty and appearance of the buildings. Their spirit was in their work, and they were thus enabled to "stamp each stone with earnest feeling." It is with the view of aiding the workmen of the present day that these lessons are put forth, in the sanguine hope that they may be of service to them.

GLOSSARY OF SOME TERMS USED IN GOTHIC ARCHITECTURE, IN ADDITION TO THOSE EXPLAINED IN THE TEXT.

ABACUS—Derived from the Greek word signifying a tray or flat board. The slab forming the upper part of a column, pier, etc.

Fig. 519.—CARVING FROM THE WEST DOORWAY OF BEVERLEY CHURCH, YORKSHIRE.

ABBEY—A term for the church and other buildings used by those conventual bodies presided over by an abbot or abbess, in contradistinction to a *cathedral*, which is presided over by a bishop, and a *priory*, the head of which was a prior or prioress. The word is generally supposed to have been derived from the Hebrew *ab*, "father," by which name the abbot was generally designated.

ALMERY, also AUMERY, AUMBRIE, and AMBRY—A recess in a wall of a church, sometimes square-headed and sometimes arched over and closed with a door like a cupboard, and used to contain the chalices, basins, cruets, etc., for the use of the

priest: many of them have stone shelves. They are sometimes near the piscina, but more often on the opposite side. The word also seems in mediæval times to have been commonly used for any closed cupboard, or even bookcase. In fact the word *armoire* is applied to such objects to the present day.

ANGEL-LIGHTS—The outer upper lights in a perpendicular window, next to the springing. It is probably only a corruption of the word "angle-lights," as they are nearly triangular.

ARCADE—A range of arches supported either on columns or piers, and detached from or attached to the wall. The word is used in contradistinction to colonnade, which is a range of columns carrying level entablatures.

BAY WINDOW—Any window projecting outwards from the wall of a building, either square or polygonal in plan, and commencing from the ground. If they are carried on projecting corbels they are called *oriel* windows. Their use seems to have been confined to the later periods. In the Tudor and Elizabethan styles they are often semicircular in plan, in which case some think it more correct to call them *Bow*-windows.

BELFRY—Properly speaking, a detached tower or campanile containing bells, but more generally applied to the ringing-room or loft of the tower of a church.

BELL-COT, BELL-GABLE, or BELL-TURRET—The place where one or more bells are hung in chapels or small churches which have no towers. Those which stand on the gable dividing the nave from the chancel are generally called Sanctus Bells.

PHOTOGRAPHY.—V.

By J. C. LEAKE.

FAILURES IN EARLY ATTEMPTS: THEIR CAUSES AND REMEDIES.

IT is hardly to be expected that the first attempt to produce a negative will be perfectly successful, even if the utmost care has been exercised in all parts of the process previously given, and we will therefore proceed to classify the failures most likely to occur, and to offer suggestions as to their causes and remedies. The defects most likely to be met with in making a negative are, first, a general clouding or fog over the whole plate after the application of the iron-developing solution; and, secondly, marks, stains, or spots in various parts of the picture. Of these the first-named is by far the most difficult to trace to its proper source, as it may arise from various causes, oftentimes from that which might be least suspected. Thus, an exposure of undue length in the camera will produce an effect of fogging which, to the inexperienced operator, might at first appear to be the result of improper chemical action, while a similar defect will result if the plate has received the slightest trace of white light during its preparation, or through an unobserved crack or hole in the camera or slide. From whatever source the defect arises, however, it must be overcome, or the resulting pictures will be flat, and deficient in light and shade, or brilliance.

If care be taken in conducting the following experiments, it will be easily ascertained by the operator from which direction the difficulty arises, and then as easily remedied. We will suppose that upon the application of the iron-developing solution the picture flashes out almost instantly, and is thin or veiled, all the details being equally developed over the whole surface, but without density and brilliance. In this case the exposure has probably been too long by at least one-half. Reduce this when trying another plate, and observe the result. If the fogging is still present while some of the detail in the shades of the picture remain undeveloped, the cause is probably diffused light either in the darkened room or in the camera. Shut out the whole of the light from the laboratory, and prepare a plate by the aid of a small candle, carefully surrounded with several thicknesses of yellow paper or calico. Insert the plate in the slide as if for exposure in the camera, and when it is enclosed allow the yellow light to enter the room through the prepared screen. Now draw up the shutter about an inch, and allow the yellow light to fall upon the exposed portion of the plate for about five minutes. Develop as usual. If any trace of an exposure is to be observed, the light is too strong, and extra thicknesses of yellow paper or calico must be added, in order to exclude it. When this test is concluded, prepare a plate in the same manner, and place it in the camera, drawing up the slide, but not removing the cap from the lens. Allow the plate to remain at least five minutes. If on development any spots of light appear, or the plate is fogged, there is probably a small hole or defect in the camera, which must of course be stopped. This is a cause of failure which often remains undetected—in fact, unsuspected—for years, and one which cannot be too carefully attended to and remedied. Should there still be signs of fogging, it may probably be now traced to the chemicals employed. If the collodion is newly iodised, and used in a bright light, it will frequently exhibit this defect, especially if it be perfectly colourless. Drop into the mixed collodion enough alcoholic tincture of iodine to reduce the mixture to a very pale sherry tint; should this fail, add to the nitrate-of-silver bath pure nitric acid, in the proportion of one drop to the pint of solution. After these additions allow the solution to rest at least three or four hours, and there will, in all probability, be no further difficulty from this cause. It should always be remembered that in working in the open air, or with portrait lenses of large aperture, it is of the utmost importance to keep the glasses shielded from the light, either by means of a fixed shade, or by holding a light board or card over them. It often happens that a very slight mist or fog in the atmosphere will, even if almost imperceptible to the eye, produce a very decided fogging upon the plate, and this must, of course, be allowed for in all test operations.

The other class of failures we have mentioned—namely, markings and spots of various kinds—are very much more easily traced to their causes, and will give but little trouble to the operator, if he will only take proper care in observing their character. Of these defects that most frequent is the presence of transparent spots of various sizes, giving the effect of holes in the collodion film. These most frequently arise from dust in the collodion or the nitrate bath. Always allow the collodion to settle for some hours before pouring it into the working bottle, and be careful that no dust is allowed to enter the bath, or to adhere to the sides thereof, when the solution is poured in. Sometimes small portions of the collodion film become detached from the plates during the sensitising process, and after floating in the solution, attach themselves to the sensitive surface when the plate is removed, of course shielding it from the action of light in the camera, and producing transparent holes of their own shape and size. To remove these the bath solution must be frequently filtered, and before commencing operations each day any scum or dust should be removed from the top of the solution. Spots with an opaque centre, or completely opaque, frequently occur when using a new camera, from the contact of small particles of metal left in the slide. All the parts of the camera and slides should be most carefully washed before use, and the joints well brushed out. Too much care cannot be expended in keeping all the solutions well filtered; and this being done, failure from spots will be of rare occurrence. Another cause of failure arises from imperfect coating of the plate with collodion. If this be not properly effected the film will be of various thicknesses, and, consequently, more density will be observable in one part of the finished picture than in others. This defect will generally be more apparent in the lower or last-coated portion of the plate than at the top, in consequence of the evaporation of the solvents leaving the collodion thicker in that part than in the other. In warm weather this frequently becomes a source of considerable difficulty, and the only remedies are the use of a collodion containing a rather larger proportion of alcohol than usual, and a rapid and dexterous coating of the plate, in order to reduce the evaporation to a minimum. The irregularity of the film is, however, easily observable before sensitising, and when it is likely to be of importance, the plate should be rejected before inserting it in the nitrate bath. Cloudy markings are also frequently caused by an improper application of the developing solution. This should be applied from the lower edge of the picture, and should flow in a perfectly even wave over the surface, sweeping and carrying away with it a little of the silver solution, which will have drained down to what was the lower edge of the plate during exposure. The developer should not be allowed to rest upon the plate, but be kept flowing in all directions, so as to become most intimately mixed with the nitrate of silver solution. Should this precaution be neglected, irregular develop-

ment will result, and stains will be made which will spoil the picture. It is also necessary to use so much alcohol as will cause the developer to mix at once with the silver solution in the film; and it must be remembered that as the ether and alcohol accumulate in the nitrate bath this quantity must be increased, or oily markings will make their appearance from irregular action, the fluid being altogether rejected from some portions of the surface. Curved lines of over development sometimes occur, either from the use of a too concentrated solution of iron, or from the insufficient quantity of acetic acid present. In warm weather, or when the chemicals are in a very highly sensitive condition, and the light intense, double or treble the quantity given in our formula may be used with advantage. Straight lines traversing the film in the direction of the surface of the bath are caused by checking the plate while it is being immersed in the solution. The dip must be made at once, and without the slightest hesitation; hence it is advisable to make use of a bath considerably larger than the plate itself, in order to prevent its catching at the corners. Wavy lines running from the top to the bottom of the plate are caused by the trickling down of the nitrate solution during the exposure. The plate must be well drained before insertion in the dark slide of the camera, and not laid flat or be reversed in position until its removal for development. It is a good plan to lay a slip of clean white blotting-paper in the slide under the plate, which will absorb any solution which may flow to the lower edge; of course a fresh slip will be required for each plate. It sometimes happens that lines make their appearance in the direction of the dip. These are often due to some slight imperfection in the bath, and the addition of nitric acid before mentioned will mostly remove them. If not, reverse the position of the plate upon the dipper, and keep it in constant motion during the sensitising process. Observe whether the lines extend to the top of the plate, and are straight, or only about half-way across, and are irregular. In the latter case either the bath is weak in silver, or the collodion has not been allowed sufficient time to set before immersion in the solution. The remedies in both cases are obvious.

We have before treated of the effect of over exposure of the plate in the camera, and we now come to that of under exposure. Of the two evils, that of over exposure is the least, and the most easily overcome, as by a little skill in development the effect of over action of light may be considerably reduced, and a tolerable picture obtained. In the case of insufficient action, however, nothing whatever can be effected, and any considerable forcing of the development will only render the picture more hard and offensive in an artistic sense. The test of proper exposure is that of development of detail in the darkest shades of the picture, and it is only when this is obtained that the work can be said to be perfect. If upon the application of the iron developer the image appears tardily, and is weak and metallic, the details at the same time being thin and poor, it may at once be considered that the action of light has been insufficient. It often happens that the operator does not sufficiently consider the quality of the light he is working with, or the character of the subject he is photographing. For instance, the time we have given for exposure in a former chapter would be ample in that particular instance, while in a close lane, or in a forest, the time must be trebled, or more than that. The remedy for this defect can at once be seen, and on no account should an under-exposed picture be allowed to pass. Sometimes, however, the effect of under exposure is produced from an improper condition of the chemicals, as, for instance, depression of temperature, the use of a decomposed collodion, or a weak and disordered nitrate bath. In the first case warm all the solutions to forty or sixty degrees. This will often effect a change as if by magic, and the pictures will develop well and rapidly. The next case is not of frequent occurrence, as bromo-iodised collodion will, if properly treated, keep almost an indefinite time. It is advisable, however, in cold and dull weather not to mix too much at once, as a freshly-iodised sample will mostly work more rapidly than an old one. In the third instance add silver to the solution, in the proportion of ten grains to the ounce; and this failing, mix a ten-grain solution of carbonate of soda, and add to the nitrate of silver solution until it is quite turbid. Filter at least twice, and add one drop of nitric acid. In all probability this will remedy the defect; but it must be remembered that no amount of exposure or of skill in manipulation will make up for bad light, and that, consequently, where the best results are required, the weather must be favourable and the light good. It is scarcely to be expected that the operator will meet with all the causes of failure which we have here enumerated, but we have mentioned these in order that he may be prepared to meet any difficulties which may arise. We should advise that all failures be met in detail, and remedied one by one; when, having been once overcome, the operator will have no further difficulties. We may now consider that a perfect negative has been produced, and will in our next paper proceed to describe the processes by which the positive prints upon paper are produced.

OPTICAL INSTRUMENTS.—XVIII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

AFTER critically weighing the value of the various safety arrangements described in the preceding papers, I believe I have hit upon a contrivance that will make the oxy-hydrogen apparatus perfectly safe for amateurs if they will but use it properly. This is described in a paper I read before the Photographic Society, February 8th, 1870.*

Highley's Interceptor (Fig. 72) consists of a brass cylinder water-chamber, closed by a screw-cap lid, through which passes a brass ingress-pipe, I, that is connected by a flexible tube with the gas reservoir. This inlet-tube is fitted with a "ball-valve," B, or a "lip-valve," L, or both, so as to allow the gas to pass in one direction only; and like Gurney's arrangement, it passes to the bottom of the cylinder, so that the bubble must rise through some three or four inches of water, before it can escape by an egress-pipe, E, screwed into the lid, that is connected by a flexible tube, T, with one of the stop-cocks, S, of a mixed gas jet, as shown in the figure. The ingress-tube is made somewhat conical inside, and the upper end is partially closed by a semi-circular dome, D, that corresponds to the diameter of a small india-rubber (or hollow metal) ball. When the gas passes from its reservoir into the ingress-tube, it drives the water before it, and the ball to the angle of the tube, where it is stopped at its widest part, to allow of the gas passing round it and on to the lip-valve, from whence it passes through the water, out by the exit-tube, on to the nozzle of the jet J. Should there by any accident or mismanagement be a greater pressure on one bag than on the other, then the gases will be driven back down that tube of the jet connected with the reservoir that is insufficiently weighted, and on to the interceptor, the water in which cannot pass the lip-valve unless it be out of order, in which case the water would rise in the ingress-tube, I, and the float-ball would be carried upwards till blocked in the dome, D, of the ball-valve, when the further passage of gas or water towards the jeopardised reservoir would be stopped; or should the weights be entirely removed from one bag, then a "suck-back" action would take place as soon as the bag, etc., was lightened, but the ball would then be sucked upwards towards the dome, and again stop the way. As Gurney's safety chamber was used in connection with one reservoir containing the mixed gases, the contingency of unequal pressure was not provided for. As we never know on which reservoir unequal pressure may arise, both must be fitted with an interceptor, as shown in Fig. 72, and the impossibility of an explosive mixture being found *in the reservoirs* in any dangerous quantity will be self-evident.

The Oxy-hydrogen Jet, wherein the two gases stored in separate reservoirs are mixed in a small chamber just before they issue from the nozzle, is usually constructed on the type shown in Fig. 73. Two separate tubes for conveying the oxygen and hydrogen from their respective reservoirs are brazed into a cylindrical chamber, wherein the gases are combined in proper proportion, by regulating the stop-cocks fitted to the end of each tube. The lime-cylinder is adjustable to and fro by means of a spring stage *that slides* between the two delivery tubes, and is rotated, raised, or depressed by means of a pin sliding in a spring tube. Sometimes the mixing chamber and sometimes the tubes are filled with Hemming's safety arrangement. When great pressure is to be used, as when the gases are

* See *Journal of the Photographic Society*, No. 214, Vol. XIV., page 208.

delivered from stout, heavily-weighted gasometers, etc., or the condensed gas-bottles, the ordinary lime-pin must be removed, and the cylinder must be mounted on a "lime-clock," so that instead of being turned occasionally by hand, it may be rotated automatically with a constant upward motion, for the following reason—viz., if only turned from time to time by hand, the limes would soon "pit" and throw the point of light out of proper focal adjustment with the optical arrangement; for so great is the pressure obtainable with the condensed gas system, that I have seen a spiral groove cut in hard limes, even while rotated by clockwork. If such a jet of ignited gases were left on one spot for a few minutes, the lime-cylinder would most probably crack and fall to pieces, and consequently cause interruption to the lecture or exhibition, or the ignited jet might be deflected from the pitted cavity back on to the condensers of the lantern and crack them. If, on the other hand, the lime rotated *downwards*, the top of the cylinder might descend below the nozzle before being noticed, and then a long pointed jet of the ignited gases would shoot over it and strike the back of the lantern, and if made of wood might set it on fire; whereas if the lime works *upwards*, a proper adjustment of jet can be made with the upper end of the cylinder at starting, and then such an accident is provided against. Moreover, any cracks are left above the jet. Such are the usual arrangements of the oxy-hydrogen jet; but considering the accidents and shortcomings the travelling lecturer has to provide against, I have designed a system that I term the "convertible jet." As it may be used with a lime-clock for high pressure or with a hand-rotating lime-pin (best suited for "soft limes," which should not be frequently turned) as an "oxy-hydrogen jet," should one of the gas-bags break down, it may then be connected with the gas main, and be used as a "oxy-house-gas jet." Should neither house gas nor pure hydrogen be forthcoming, then instead of being placed *hors de combat*, it may be used as an "oxy-spirit jet," so that it may be converted from one arrangement to the other, according to requirement and the will of the operator. This contrivance was described in a paper on "Lantern Construction" read before the Edinburgh Photographic Society, April 7th, 1869, and published in the *British Journal of Photography*, May 21st, 1869.

Highley's Convertible Jet.—Commencing with the supporting-rod and clamp, I think I may safely say most workers must have experienced the difficulty of firmly clamping any ordinary form of burner or jet—that has, through its length, much leverage—on to the thin rods usually attached to the lamp tray. To overcome this serious defect, I tried larger rods and powerful clamps made on the French method for telescopic joints, but with slight advantage, till I hit upon the simple plan of filing away the side of the supporting-rod opposite the thumb-screw, so that two sharp edges were left to bite on to the adjusting rod, as shown in Fig. 74; R being the rod, T the sliding tube working over it, and S the clamp-screw. The main portion of the jet is shown in Fig. 75; S being a sectional side, and T a top view of the disposition of the oxygen (O) and hydrogen (H) delivery-tubes, the stop-cocks, nozzle, supporting-rod R, and clamp C. The gas-tubes are free from all impediments of safety dodges, as I prefer a clear gangway, that allows of the nozzle or tubes being freely got at if accidentally clogged with dust, etc., and putting my dependence for safety on constant and equal pressure, as previously advocated. The mixing chamber is a modification of the arrangement previously shown in Fig. 68, page 124. The tube that carries the nozzle pulls off, so that coarse or fine bores can be fitted according to the amount of pressure to be employed or special arrangement selected. The bore of the nozzle, in relation to the pressure employed, is a matter of importance in the proper construction of a jet; for if too large, the gases run back and burn within the nozzle tube, often causing a series of sharp explosions, which, if not dangerous, are unpleasant to the ears of a nervous exhibitor or of the audience.

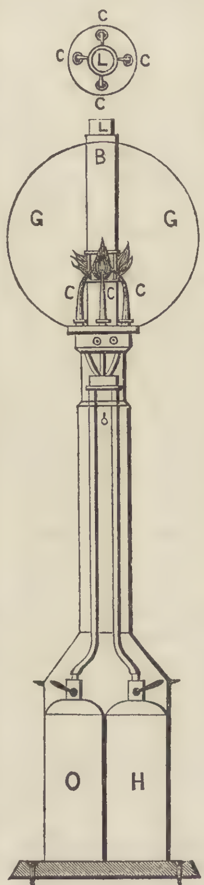


Fig. 71.

Fig. 76 shows the ordinary arm for supporting the lime-ball L, whether the "convertible jet" is employed for the "mixed gas" or "oxy-house-gas" arrangement. The lime is supported by a pin, P, long enough to hold two limes, as shown in Fig. 77, for the purpose of keeping a reserve lime warm and ready for action, should the one in use crack; and is adjusted by a screw-pin, S, the support being clamped between the gas-tubes, H, O, by a nut, N.

Fig. 77 shows a lime-clock supported for the lime-ball L, that replaces the ordinary arm, if great pressure is to be used, especially when the condensed gas bottles are to be employed. This is one-half the size of the ordinary or old lime-clock, and is worked by a spring and cog, instead of the catgut action. K represents the key of the lime-clock; and, to facilitate winding up without disturbing the adjustments of the jet, the clock is supported on a little tray, T, that is clamped by a nut, N, between the gas-tubes, H, O, so that it can be removed bodily from the lantern; the tray allows of the lime being adjusted nearer to or further from the nozzle for producing the best light attainable.

Lime-tongs should be employed for the removal of hot cracked lime-cylinders.

Fig. 78 shows in section the spirit-lamp reservoir R, with the double wick, W, and the lime and support, L, S, with the air-way, F F, for keeping the reservoir cool, that has been described in detail in the previous papers on this subject, and likewise can be adjusted and clamped by a nut that slides between the gas-tubes, H, O. When this oxy-spirit jet is used, the stop-cock of one tube is closed, the other being connected with the oxygen reservoir; that gas being then projected from the nozzle on to the lime-cylinder.

Fig. 79 shows this jet with the lime-pin in position for connection with a house supply, and a bag of oxygen weighted with 56 lb. or with both gases in reservoirs each weighted with 112 lb., and fitted with an arrangement that allows of the lime being turned from outside the lantern, so as to avoid the necessity of constantly opening and shutting the side door as is the case when the lime is turned by hand. This is effected in the following manner:—It will be observed that the lime-pin, P, is attached to a stout tube, F, that can be worked by a female screw, upward or downward on a coarse-threaded male screw, S, fixed to the clamp, fitting with sufficient range to present in turn the entire surface of the lime-cylinder to the nozzle J. To the tube F a small drum, W, is fixed; a similar drum, *w, works up and down* on a screw cut on the clamp-tube T, that slides over the supporting-rod R: a cord wound round the drum W, can be unwound by the rotation of the drum *w*, and thus give the necessary motion to the lime from the back of the lantern. To secure a sufficient change of position from the spot where the ignited gases previously fell, without having to look at the lime itself, the head of the drum *w* is made square, as shown in the figure at *a*: all that is required is to turn round a flat face of this square, till that which was at the back stands to the side, and so on, every time the lime is seen to be pitted. This arrangement to a great extent obviates the necessity for lime-clocks, a matter of consideration when jets are intended for abroad, where it is not always possible to repair such delicate arrangements. The contrivance here described is not likely to get out of order, but if so, it can readily be repaired, supposing always that the apparatus is *substantially* made in the first instance, and not in a cheap and therefore almost worthless manner; for it must always be borne in mind that the best workmanship always proves the cheapest in the long run, and there is a wonderful difference between any article being really cheap or simply low-priced. This remark especially holds good with such objects of manufacture whereon human life may depend, whether it be a gun, a steam-boiler, or a gas-jet.

Lime-light Jet for Spectrum Demonstration.—The spectra of many bodies may be shown by fusing small quantities of material

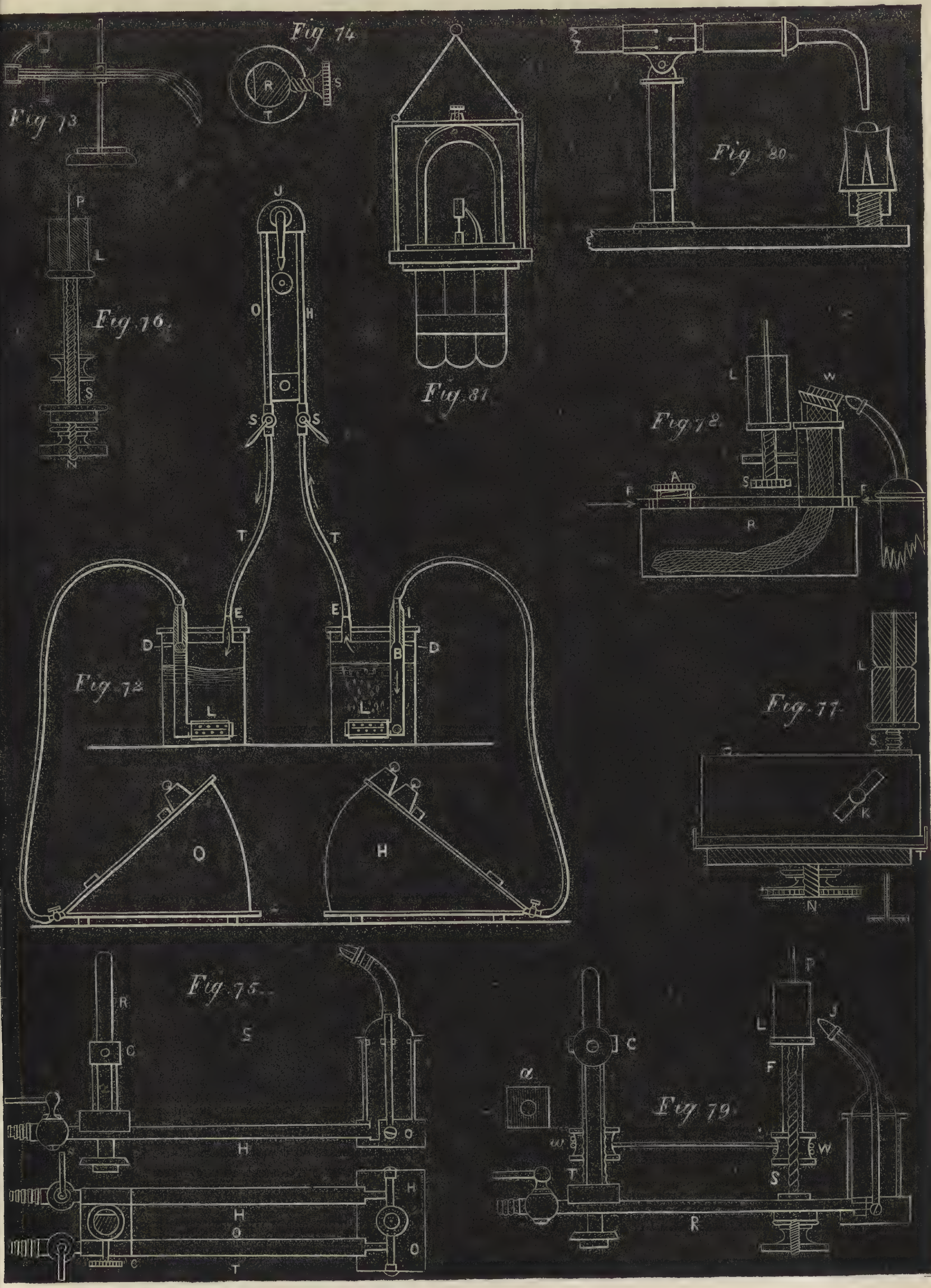


Fig. 73
Fig. 74
Fig. 81
Fig. 80
Fig. 76
Fig. 78
Fig. 72
Fig. 77
Fig. 75
Fig. 79

in a cup-shaped cavity worked in the top of a cylinder of lime, on which the oxy-hydrogen jet can be directed, when placed in the focus of a spectrum arrangement. The form of jet suited for this purpose is shown in Fig. 80. This may often be used when the expense and trouble of fitting up the electric lamp would be inconvenient.

Lime-light Lamp for Illuminating Museums, etc.—A strong feeling is growing up that our public museums should be opened at night for workmen and others who are confined to business during the day, and the question has been several times discussed in Parliament. Unquestionably any system that involves the distribution of gas-piping over public buildings intended for the conservation of scientific or artistic treasures, is objectionable, on grounds quite distinct from the question of probable injury to pictures, etc., through fire; for in case of a conflagration, a train of fire is laid by means of the gas-pipes to extend the mischief, even though care may have been taken to guard against extension. How often has it happened (especially at our theatres) that the provisions made against fire have not been accessible or are out of order just when they were really needed. The cheapest and safest light that could be employed for lighting scientific museums, and most probably art-galleries also, would be a lime-light lamp, wherein the jets were fed by pure dry hydrogen and oxygen condensed in the bottles previously described at page 123, Fig. 61. A suitable form of standard lamp I designed for this purpose is shown in Fig. 71, the gases from four nozzles, marked C, fed from the bottles, H, O, impinge on an automatically ascending cylinder of lime, L, which is covered by a thin metallic guard, B, the light being dispersed by a large ground-glass "moon globe," G G. This arrangement can be placed in position, and removed at pleasure, and the gases being isolated, any accident, or extension of accident, would be impossible; for, as I have previously stated, any conflagration or explosion with such bottles is impossible, as could be readily tested at Woolwich or elsewhere. Each day the empty bottles could be replaced by fresh ones, and as they would be enclosed, under lock and key, in the case of the standard, none but an appointed attendant would have access to them. As the lime is simply rendered incandescent by ignited gases that give off no injurious vapours, and the process is not one of ordinary combustion, neither carbonic acid, sulphuric acid, nor sulphuretted hydrogen can be produced, as in the case of illumination by ordinary house-gas. The only doubtful question is, as to whether the sublimed lime vapour given off in *small quantities* during the period of ignition would in time exert an injurious influence on oil paintings, etc., as the lime would be slowly distributed in impalpable powder through the atmosphere unless carried off from a closed globe by a special contrivance. Such powder would be lime in a caustic state, and this moreover would "slack" in a damp atmosphere, so that a lengthened series of experiments would be necessary before this arrangement could safely be employed in a picture-gallery *with an open globe.* From a sanitary point of view this would be a good arrangement for public rooms; for as the incandescent lime takes all the oxygen it requires from the gas-bottles, it in no way abstracts oxygen from the air of the room which it illuminates, or leaves an undue proportion of nitrogen, as is the case with the ordinary combustion of house-gas or oil-burners, which, with carbonic acid gas, another product of their combustion, tend to establish a stifling atmosphere. Again, the heat from the lime-light speedily diffuses itself through the atmosphere in all directions, and is much less in proportion than that given off from a series of burners that would give an equal amount of illumination. As previously stated, were there a demand, both pure hydrogen and oxygen could be produced on a large scale at a very cheap rate.

Submarine Lights are employed for diving operations, attracting fish at fishing-stations, etc. Fig. 81 shows an arrangement devised by Mr. Sykes Ward. It consists of a series of condensed gas-bottles, connected with a lime-light jet, enclosed under a double glass shade, the outer shade being provided to keep the cold water from contact with the inner heated one. A few years since, I fitted up an electric regulator on a similar plan for a fishery company. In either arrangement an air-tube is not required, as the lights are not dependent on the ordinary process of combustion.

India-rubber Connections are requisite for joining the generators to the gas-reservoirs, or the latter to the jets. I find the red rubber flexible tubing more lasting and free from the unpleasant smell of the ordinary vulcanised rubber tubing—which is always unpleasant to handle—and is more pliable than the old-fashioned plaited tubing. When it has to be laid in places where it is subject to be trodden on, it should be used with a spiral wire core, as a preventive to the gas being pinched off, and the light put out. The *Scientific American* gives a method for rendering gas-tubes impermeable, and rendering any escape impossible. "This can be done by giving the tubing a thin coating of a varnish made by dissolving $1\frac{1}{2}$ parts of treacle and 2 parts of gum arabic in 7 parts of white wine and $3\frac{1}{2}$ parts of strong alcohol. The treacle and gum must first be dissolved in the beer or wine, and the alcohol must be added very slowly, constantly stirring the mixture, or the gum will be thrown down."

If it be necessary to connect pieces of tube so as to form greater lengths, this may be effected by "connecting-pieces" made of brass tube, a shade larger than the bore of the rubber tubing, their ends, on to which the two pieces of tube are sprung, being ribbed to secure a perfect fitting.

FISH CULTURE.—V.

By Greville Fennell.

ARTIFICIAL FISH CULTURE AT HUNINGUEN.

The importance of fish culture as a means of procuring cheap and wholesome food is now so universally recognised that we need make no apology for extending our articles on this subject, and noticing at as great a length as our space will permit the efforts that have been made, and are still making, by individuals as well as societies, to bring fish into a closer rivalry with butchers' meat than it has hitherto attained. Among other societies and places where experimental fish culture is carried on, we have already mentioned the grand French establishment of Huninguen, but instead of giving the past history in detail of this important institution, it will doubtless be more acceptable to employ our limited space with the last accounts from that seat of pisciculture, which we extract from the petition of the German Fishery Association of 13th of February last to Count Bismarck.

"An establishment for artificial fish culture was founded by the Emperor Louis Napoleon at Huninguen, on the Rhine, at a great expense, for the purpose of re-stocking the French waters. Up to the present year the establishment has hatched out a large number of fish eggs, and has distributed them, both to public waters and to private persons. Though the results, as far as is known to the Fishery Association, have not entirely corresponded with the great outlay, it nevertheless cannot be denied that the whole establishment, which is on an extensive scale, and rationally and properly managed, will be of great use to our rivers and waters. It is, unquestionably, in the interest of the German fishery to maintain this establishment, and make it over to a German management, whose object and calling must be the encouragement of fish culture, the increasing and permanent multiplication of fish in all the German waters, and, naturally, to specially care for the Rhine and tributary rivers. If the establishment and existing materials—based on the experiments which have been made in France, England, Scotland, Ireland, and latterly in Sweden and Norway, in this matter—are properly used and supported by the technical experience she can command for a scientific superintendence of the operations, Germany, rich in waters, but by its own fault poor in fish, would vie easily with other countries in the production of fish. To attain this it is necessary to reform our very deficient laws in this respect, to raise up an interest for fish culture, to give instruction and all possible protection to those who carry on such hatching establishments. The German Association recognising this, has undertaken the task, and hopes to be able to reckon on the support of your Excellency and the German Government," etc.

"The Rhine," says another petition from and to the same, "one of the most beautiful rivers in the world, is specially suitable, by many tributary rivers, for the production of the better fish—namely, the salmon—in great quantity and quality. Year by year the produce has diminished, and all attempts at fish culture—the check of close time and similar measures—can lead to no results as long as they are not introduced and really

carried out by the whole territory of the river, and particularly at the mouths of the river. The states on the river's banks recognising this have entered into a treaty at Mannheim on the 27th November, 1869, on the common regulations of the fishery in the Rhine from Basle downwards. This treaty was laid before the representatives of the different states by the governments, and was everywhere, even in the Prussian Landtag, almost unanimously accepted, but was unfortunately rejected by the Dutch Lower House. In the discussions in Holland, the suitability and the necessity of the regulations for the protection of the fishery were acknowledged, even by many of the opponents of the treaty; but in this case it was repugnant to the unjustifiable pride of the Dutch to make restrictive regulations for Dutch subjects in consequence of a treaty with other states, and it was proposed to the government that the regulations of the treaty should be embodied in a law and again brought forward in this form. Hitherto, as far as the Fishery Association knows, this has not been done; and we therefore venture the request that your Excellency should urge this question through the German Ambassador, and demand of the Royal Netherland Government that it remedies the abuses which it has itself acknowledged, through participation in the above-named treaty. Should the Dutch continue to fish as they do in late years, as, for instance, drawing nets through the river with small steamboats, which entirely close it, and at times when the weak and half-sick salmon descend the river; when with them there is no close time and partial freedom of the river given—there can be no useful results to the Rhine fishery either from the establishment at Huninguen or the judicious administration of the water, and soon salmon will be found in the zoological museums on the Rhine, but no more in the Rhine itself," etc.

By a decree of his Excellency the Minister of Agriculture, we further learn that "the larger fish establishments of the province in the north can claim the public interest for themselves on the ground that they offer a valuable though not certain means of preserving the riches of those waters in valuable fish, or to restore them. For these reasons I am inclined to subsidise the establishments, as far as public means are disposable for the purpose; only such grants must be in a form and under conditions which in some respects ensure the intended common object. Therefore, the form to choose in preference for the State grant, will be that the greater quantities of the young—at least five months old—Rhine salmon, salmon, and trout, be obtained for a moderate price in the current year, to be turned out direct into the waters. The receiving and the turning out of the fish will be consequently confided to an expert. It is scarcely to be doubted that the management of the rearing employed, and particularly the sort of nourishment which will be given to the young fish on the spaces of the establishments, is of important influence in their power to maintain themselves when turned out in the waters, and therefore particular regard will be paid, on the reception of the fish and settlement of the price, to a judicious course in rearing."

There are other governments actively bestirring themselves in the practical development of fish culture, while England, admitted to be the most forward in its pursuit, is left without other support than that derivable from the purses and public spirit of private persons.

An important feature in the arrangements of the establishments at Huninguen may not be passed over. Courses of rough stones and a due quantity of weed only line the banks. Thus every stone becomes a means of shelter and concealment. The adult trout have submerged holes and crevices made for a like purpose. This provision we have often insisted upon in our trout streams, and even in our larger rivers; but for the most part so obvious a necessity in accordance with the nature and the habits of trout is strangely neglected. Thus, constant walking up and down the banks of a river in which there are no hiding-places for the fish will chase and distress the trout in the stream to an extent that will drive them into other more quiet waters, that have harbours of refuge, if they have any chance of escaping. There should always exist hiding-places, particularly for trout. Roots of trees, large stones, under the aprons of weir and mill tails, and even eel and rat holes are all places to which trout will rush when a sudden fall of water takes place or they are unduly disturbed. In a mill-tail on the Itchen, between Twyford and Bishopstoke, in which trout lay in abundance, the water was suddenly let off to about an inch in depth; the trout were seen dashing here and there while the stream was subsiding, and most of them made for the apron and the deeps below, but upon examining three holes in the sand in the centre of the bed of the river, four fish of above a pound in weight were found in one hole, and three in each of the others.

FARMING AND FARMING ECONOMY.—X.

By Professor Wrightson, Royal Agricultural College, Cirencester.

BEANS, PEAS, ETC.

Lawson describes eight varieties of field and fourteen varieties of garden beans. Restricting ourselves to the former class, we notice the following as among those most widely grown:—

The common Scotch, or Horse Bean, is almost the only sort cultivated in Scotland. The shape and colour vary with soil and climate. It is generally "slightly irregularly compressed, and wrinkled on the sides, and frequently a little hollowed or flattened at the end; of a whitish or light-brownish colour, occasionally interspersed with darker blotches, particularly towards the extremities; colour of the eye black; straw 3 to 5 feet in length; average weight, 62 lb. per bushel." "In a warm, dry summer, the sample is always more plump and white, particularly if the harvest is also dry, and especially if cultivated on a strong clay, and drilled instead of sown broadcast." The great diversity is also owing to a mixture of varieties, sown together, and recognised under a common name. That such a mixture exists is evident to any one who examines a field of these beans in full flower, when they will be seen to present an infinite diversity in colour. Such differences are sufficient to constitute varieties, and therefore the seeds are more likely to vary than if the flowers were all the same.

The common Tick Bean is held in the highest estimation in England. It is shorter in the straw, and the seed is smaller, more cylindrical, and more rounded at the ends, than the last. It is also better adapted to light soils. *Harrow Ticks* are still smaller and finer than common ticks, and besides these there are *Essex Ticks*, *Flat Ticks*, and *French Ticks*, which chiefly differ from common ticks in being suitable for special descriptions of soil.

Winter or Russian Beans constitute a well-defined variety, characterised by their hardihood, enabling them to stand the rigours of winter, their shortness of straw, fineness of grain, and early period of ripening. This variety was introduced into England in 1825, and is considered by some agricultural writers to be identical with the *Heligoland Bean* (Lawson).

Messrs. Raynbird, Caldicott, and Co.'s list of seed corn for 1871 indicates the following varieties to be in demand:—*Horse or Tick Bean*, weight, 64 lb. per bushel; hardy and prolific. *Cluster Beans*, early and prolific, and of fine quality, often weighing 68 lb. per bushel; straw short. *Early Mazagan Bean*, larger than the tick bean; stalk tall; requires good land, and is suitable both for garden and field culture; weight per bushel, about 58 lb. *Long Pod Bean*, stalk stout and tall, grain large; comes late to harvest. *Broad Windsor Bean*, extensively cultivated in gardens, may be grown as a field crop with advantage upon good land. *Winter Bean* may be sown in October, and will be ready for harvest by the end of July.

Besides these, Lawson describes *Pigeon Beans*, an early, prolific dwarf, and small seeded variety; *Purple Field Beans*, a variety resembling winter beans; and the *Alexandrian Field Bean*, which grows about the height of the common horse bean, but is later in ripening, and is of a dull reddish-brown colour.

Beans are suitable for stiff clay soils, excepting winter beans, which may be grown successfully on lighter lands. The Norfolk rotation may be conveniently lengthened and modified by introducing this crop into it. Thus half the barley land may be seeded with clover, and half with beans, the result being that the interval between clover crops is increased from four to eight years. In courses of cropping suitable for clay districts, beans always occupy an important place, very frequently preceding wheat, for which they are an excellent preparation. (See Rotation of Crops, Vol. II., page 261).

In some cases clay soils have been alternately planted with wheat and beans for a succession of years, and under certain circumstances such a course may be followed with advantage. These two crops are especially suitable for stiff soils, while root-crops cannot be advantageously cultivated upon them. Bean cultivation allows of a thorough system of inter-tillage. While,

therefore, it enriches the land for wheat, it also allows of cleaning operations being carried on, and hence both the principal objects of cultivation are attained. Again, crops are to be looked upon as exhausting or renovating, according to the use that is made of them. Beans sold off the premises of course tend to drain the soil of its valuable plant-producing constituents, but if fed on the farm in the form of bean-meal, and returned to the land, the soil is benefited to much the same extent as by a turnip-crop consumed in yards. In this case we should have a course of cropping suitable to the natural requirements of the land, while in the case of turnip-culture we should run into endless difficulties. The objects of the farmer should be to obtain the largest amount of produce with the least expense, leaving the land in the best condition; and such a system as the above would probably accomplish these objects, with the help of efficient steam tillage and a judicious use of purchased manures.

PREPARATION OF THE SOIL, SOWING, ETC.

In the case of winter beans, the wheat or oat stubble is grubbed, harrowed, and weeded. The weeds are carried off, or burnt and spread on the surface. Dung at the rate of from twelve to fifteen loads is carted and spread, and the land is ploughed 4½ or 5 inches deep. The beans are drilled in October, 2 to 2½ inches deep, 18 to 24 inches apart between the rows, and at the rate of 2½ bushels per acre. Should the land be clean, the preparatory work may be commenced with carting out manure on the untouched stubble. The cultivation of spring beans does not differ materially from that of winter beans, the land being similarly prepared and the seed sown as early in the succeeding season as convenient. Probably no crop has been cultivated in so many different ways as beans. To give even a brief description of each method would far exceed the limits of the present paper. We must therefore be content with little more than naming the principal ones. *Broadcasting* on an ordinary ploughed furrow is to be avoided as slovenly, and likely to end in the land becoming foul. *Broadcasting* on a ribbed surface —*i.e.*, a surface raised into smaller or wider ridgelets, or drills, either with a small ribbing plough, or an ordinary plough—is not objectionable, as the method allows of interculture. *Drilling* is perhaps the most widely-used method, the coulters being placed from 18 to 24 inches apart. Beans are well adapted for *dibbling*, a process already described (see under Wheat, page 86). In Norfolk the land is marked out with a drill, in rows 14 inches wide, and beans are dibbled along the tracks of the coulters at 4s. per acre. In Holderness, Yorkshire, the land is winter ploughed, and in spring so lightly harrowed that the furrows are not obliterated. Beans are dibbled, one in each hole, in every seam, or every alternate seam, or from 10 to 20 inches apart, and 5 or 3 inches apart in the rows, respectively. The cost of this operation is 6s. per acre. Beans are also *ploughed* in. They are deposited at the bottom of the furrow by the bean-barrow, which follows immediately behind, and is attached to, a plough. The beans may be thus sown in every furrow, in alternate furrows, or in every third furrow. No crop is more suitable for a mixed system of cultivation. Thus Mr. Morton relates how he grew carrots and beans in alternate rows for many years, with success. Cabbages and turnips may also be planted or sown between wide-drilled beans, and occupy the ground after the main crop has been harvested.

Beans are occasionally "blended" with peas, and also with vetches. Both plans are excellent, as the strong bean-stalk offers an excellent support to the weaker plant with which it is associated. In the case of peas we must use the common grey field variety, or, at least, some kind which will ripen simultaneously with the beans. Vetches intended for seed may be conveniently separated by means of a sieve after thrashing. During the droughty season of 1864, Mr. Mechi recommended beans to be cut as a forage crop and used as a green food.

AFTER-CULTIVATION AND HARVESTING.

The after-cultivation of beans should be vigorously pursued with both hand and horse hoes until the plant flowers, when working among them will do harm by knocking off the incipient pods. Winter beans are early ready for cutting, while spring beans are usually the last crop harvested.

Beans are ready to cut when their leaves fall. Cutting is effected by means of the reaping-machine or by the hook, and beans require a considerable time before they are fit to cart. The crop is rendered uncertain through the attacks of the black dolphin (*Aphis Fabæ*), which frequently devastates bean-fields. The only remedy is to cut off the tops, upon which the pest usually settles, and to carry them away and burn or bury them.

PEAS.

Peas are divided into classes according to the colour of their flowers. In the first division the flower is white, with white or bluish-coloured seeds, commonly known as garden peas. In the second we commonly find coloured flowers, and grey, dun, red, or speckled peas, commonly called field peas (Lawson). We have, therefore, here, as in beans, two sub-species, *Arvense* and *Hortense*, and there is also an intermediate class, *Arvense vel Hortense*. Among the numerous varieties recommended for field cultivation we name the following:—

Common Grey Field Pea.—A late variety often sown in combination with beans on strong land; very prolific; straw forms excellent fodder.

Early Grey Warwick, or Nimble Hog.—Pods often in pairs; length of haulm 2 or 3 feet; earlier than any other of our cultivated peas. Apt to burn up in dry seasons.

Grey Hastings.—Resembles the last; pods and straw are longer; ripens three weeks later.

Partridge or Maple.—Pods broad, and contain five to seven seeds of medium size, and of a yellowish-brown colour, speckled with darker brown, and with light-coloured eyes; average length of straw 4 feet. Earlier than the last variety.

Grey Rouncival, Giant, or Dutch.—The tallest, latest, and largest field pea; length of haulm 6 to 8 feet.

Winter Pea.—Hardy, standing the severest winters. Seeds very small and dark-coloured; straw about 4 feet long, small and hard. Ripens very early when sown in October, but is later than most other varieties if sown in March.

In Messrs. Raynbird's lists for 1871, *Early Dun*, *Winter*, *Maple*, and *Early Emperor* are varieties advertised for sale.

CULTIVATION, ETC.

Peas are more delicate than beans. They require a lighter soil, and grow best on lands of a calcareous character. They occupy a similar place in rotation with beans. A similar cultivation to that recommended for beans will be found equally suitable for this crop. Peas are sown in March, either by the drill or broadcast, on a ribbed surface. Occasionally they are sown broadcast upon an ordinary furrow, a plan to be deprecated, as causing land to become foul. About three bushels of seed is sufficient, and the distance apart between the rows will be from 10 to 12 and up to 16 inches. No crop is more uncertain than peas, and it is difficult to recommend any suitable manure for them except farm-yard dung. A case is recorded in which a great effect was produced by the application of 8 cwt. of gypsum and 4 cwt. of common salt to a failing crop of peas. This is scarcely to be wondered at when we remember the partiality of this plant for lime and limy soils.

As many as sixty-two bushels of common grey peas have been grown. Forty-eight bushels are a maximum crop in Essex; twenty-four bushels are a fair crop without manure, and twenty-eight a fair average with manure. In bad pea seasons, the yield will, on the best soils, not average twenty-four bushels per acre, while on the inferior classes it will not be more than ten or twelve bushels per acre (J. Hannam in Morton's "Cyclopædia").

We have endeavoured to present to our readers some of the main facts regarding the principal cultivated crops. The study of each of those crops might have been approached from a botanist's, a chemist's, or an economist's point of view; but the foregoing facts must commend themselves to the farmer's mind as important. The best varieties, the soil suitable, the place in rotation, the preparation of the land, the planting, after-cultivation, harvesting, preparation, cost, and produce of the crops are all essential, while questions of composition of botanical differences, etc., however interesting, must be looked upon by the farmer as of secondary importance.

Many other plants occupy a place in British agriculture, but the foregoing are those which are co-extensive with our country. We therefore leave the consideration of flax, hemp, hops, teazles, woad, madder, coriander and caraway seed, buckwheat, canary seed, etc., as scarcely forming an integral part of our farming economy.

FORTIFICATION.—IX.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DETAILS OF WORKS.

It is obvious that the guns intended for the defence of a work must either fire over the parapet or through openings made in it; and until recently there have only been two arrangements by which this could be effected—viz., by embrasures or barbettes. Mortars were the only species of ordnance which fired their projectiles over the parapet without themselves being visible, and exposed to the enemy's direct fire. The invention by Captain Moncrieff of a special carriage, which enables the guns to fire over the parapet *en barbette* and yet to descend to a position of security behind it while being loaded, seems to combine the advantages of both these methods, with but few of their defects, and there can be little doubt that if some inexpensive arrangement can be devised, by which the ordinary field or travelling gun-carriages can be rapidly converted, so as to act on the Moncrieff principle, it will to a great extent supersede in field-works the other methods referred to.

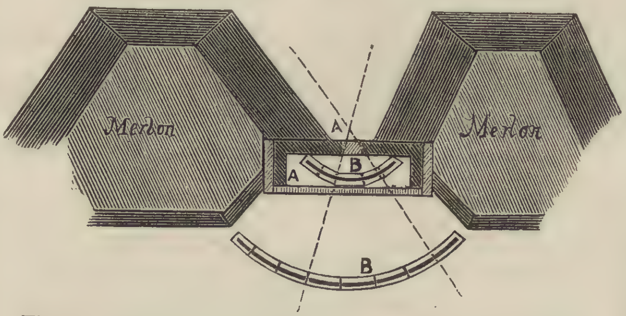


Fig. 62.—PLAN OF ONE GUN PORTION OF A COAST BATTERY, EARTHEN EMBRASURE, AND IRON SHIELD.

A, A, Shield and Supports. B, B, Iron Racers on Granite for traversing Gun.

Embrasures are openings made through the mass of the parapet, at such a level that the guns and gunners are completely protected from the enemy's direct fire, except such as may enter the work through the embrasure itself. To reduce the chance of this to a minimum, embrasures are made as small as is consistent with a sufficient lateral range for the guns, and the space that is necessary to prevent the destruction of the reveted sides or *cheeks* of the embrasure by the explosion of the charge. In the accompanying diagram (Fig. 63) the shapes of the various types of embrasures in earthworks are given, as well as the names and ordinary dimensions in feet and inches of the most important parts. Their general plan is a funnel-shaped opening, of just sufficient size at the *neck* to admit the muzzle of a gun (2 feet), and gradually widening outwards to allow of the gun being traversed through a certain horizontal angle. It is readily seen that the larger this angle is, the thinner and weaker the parapet becomes on either side of it; and the amount of protection afforded becomes very small indeed if the embrasures are very oblique to the parapet, or if the embrasure is necessarily large to enable the guns to follow with their fire objects moving rapidly past them. This latter is the case with coast batteries, and it has been found so impracticable to strengthen the weak points of embrasures of this kind by any ordinary means, that iron shields are almost universally adopted, in spite of their great expense. Embrasures are said to be *direct*, or *oblique* when the centre line or directrix is at right angles, or oblique to the crest line of the work; and the terms *sloping* and *counter-sloping* are applied to indicate that in the former case the bottom of the embrasure or *sole* slopes downwards, to admit of the gun being fired at a depression, while in the latter the guns are only intended to fire at a high angle of elevation, and consequently the *sole* slopes upwards from the muzzle of the gun. This arrangement has the advantage of diminishing the size of the external opening or *mouth* of the embrasure, and may be advantageously used in batteries for bombarding towns, etc., where it is known from the commencement that the guns are only intended for distant fire. Countersloping embrasures are used for howitzers, which, from being very short, require in most cases more elevation than guns for corresponding ranges. The formation of embrasures in a parapet involves the removal of large quantities of earth from it, and its powers of resistance are consequently considerably weakened. It therefore is desirable not to place them as close to one another as the guns might have been placed had they been firing over the parapet. The actual space required for each gun and its detachment is 15 feet, whereas guns in direct embrasures should not be less than 18 feet apart from centre to centre; and in oblique embrasures not less than 22 feet. The block of parapet between the embrasures is called a *merlon* (Fig. 62). The term *genouilliere* is applied to that portion of the parapet between the ground or platform, and the *sill* of the embrasure, or the edge formed by the intersection of the sole with the interior slope. The field carriages in the British service admit of guns being fired over a genouilliere 3 feet 6 inches high, and for the garrison carriages 2 feet 3 inches is sufficient. In the Prussian service the guns can be raised on their ordinary carriages so as to fire at a height of from 5 to 6 feet, thereby obviating the necessity for an embrasure, or at all events a very shallow one will suffice. Embrasures are liable to be destroyed or damaged both by the fire from without as well as by the discharge of their own guns, which sets fire to or bursts the gabions with which they are usually reveted (Fig. 64). This latter is a serious defect, and can only be met by widening the embrasure sufficiently just beyond the neck. In siege batteries, where the guns are only required to fire in certain well-defined directions, and where, moreover, they are certain to be opposed by an accurate fire, the external opening is made only 2 feet 6 inches wide, and as it approaches the muzzle of the gun opens out in a curve. This is called the oval embrasure. It is tedious to make, but stands fire well. The revetment is secured from the effects of the flame by a covering of prepared hides. Howitzers being so short that the explosion takes place inside the battery, render it necessary to leave the neck of their embrasures unreveted at the natural slope of the soil.

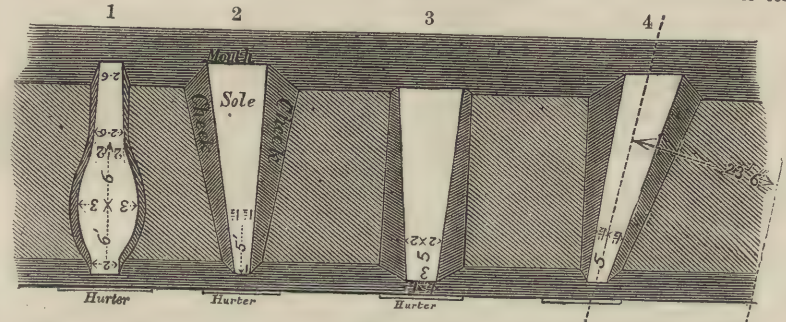


Fig. 63.—EMBRASURES—1, 2, 3, DIRECT (1, OVAL; 2, SLOPING; 3, COUNTER-SLOPING). 4. OBLIQUE.

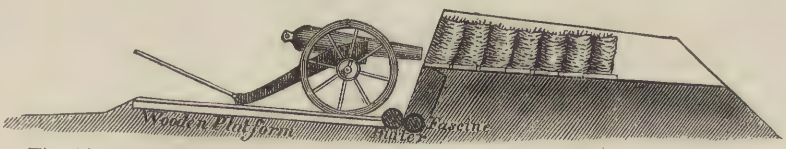


Fig. 64.—SECTION THROUGH A SLOPING GUN EMBRASURE IN A FIELD-WORK.

Barbettes are raised platforms or mounds of earth on which the guns are worked, to fire over the crest of the parapet. They

are made consequently in our service 3 feet 6 inches below the level of the crest. Their size is dependent on the number of guns for which they are required, a rectangular space 15 feet broad by 20 feet long being allowed for each gun. When a gun is placed at the salient of a work, and intended to be used either to fire on the capital or at right angles to either face, care must be taken that there is room for the gun in any of the three positions. Guns are run on to the barbettes by means of ramps or inclined roadways, which are usually not less than 8 feet broad, nor at a steeper slope than 1 in 6. They should be placed on the side least exposed to fire. Barbettes have the advantage that they enable the guns to cover with their fire a large area; but on the other hand the gun detachments and guns themselves are very much exposed, and must be destroyed or silenced when an accurate musketry fire is brought to bear on them. Perhaps the greatest example in Europe of the system of defence by barbettes is in the new works at Antwerp, where almost the whole of the direct artillery defence is arranged on this principle.

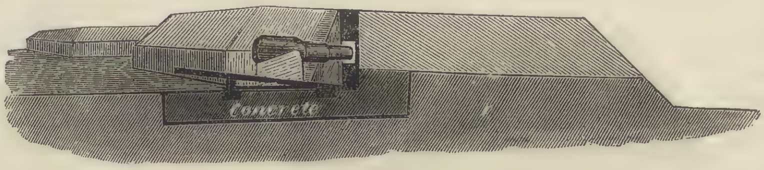


Fig. 65.—SECTION THROUGH SHIELD AND EMBRASURE OF A COAST BATTERY.

From what has been said of the relative advantages and defects of barbettes and embrasures, it will be seen that either one or the other must be adopted, according to the circumstances of the case. The salients of works seem the best positions from which to derive the full advantages of guns firing *en barbette;* whereas, in the flanks, where great lateral range is not required, and where a direct artillery attack is not to be feared, embrasures would appear to be most advantageous. The gunners working on a barbette may be, to a certain extent, protected from fire by increasing the height of the parapet right and left of the gun. An auxiliary parapet or traverse of this kind is called a *bonnette.* The men working guns in embrasures may be protected from musketry fire and splinters of shells by *mantlets,* which may either be a sort of shutter of wood plated with sheet iron, which is suspended or pivoted on a bar running across the top of the embrasure; or may be made of two or three thicknesses of rope sewn together, to form a sort of curtain or flap, which is only raised when the gun is ready to fire. Mantlets of this kind were used by the Russians in the defence of the works at Sebastopol; but there the gun fired through a small port in the mantlet itself, which did not move.

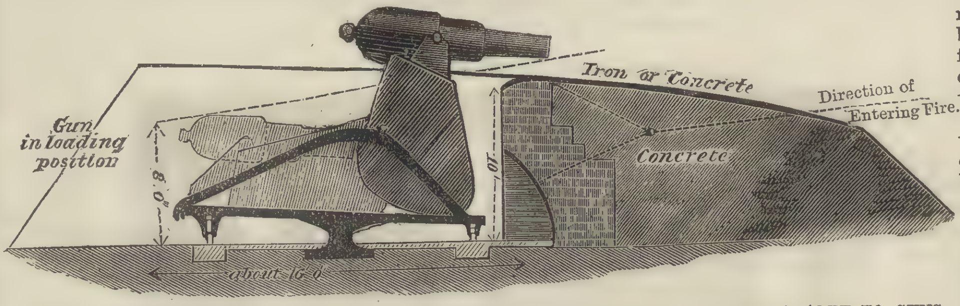


Fig. 66.—SECTION SHOWING THE AMOUNT OF PROTECTION AFFORDED BY THE PARAPET TO GUNS MOUNTED ON MONCRIEFF CARRIAGES.

In coast batteries, an ordinary type of which is given in Fig. 65, the works are of a permanent nature, and are armed with the heaviest artillery. They have to cope with a sudden and perhaps concentrated fire from ships moving rapidly past them, and firing as heavy and probably more shots per minute than the battery. Under these circumstances the only advantages possessed by the battery are, that its guns are firing from a steady platform, and that, if properly constructed, it does not suffer so much damage when hit as it inflicts on the vessels. What is more to be apprehended than the actual dismounting of the guns by the enemy's fire (which is probably not very accurate) is, that some of their shells will burst in the battery, and either effect the explosion of the magazines, the doors or windows of which must at such times be open to supply ammunition; or cause to explode by concussion or some other way the numbers of large shells full of powder, which are placed close to each gun for use. Every endeavour therefore must be made to ensure a rapid and secure means of supplying powder, shells, etc., to the guns, while the guns themselves must be isolated from one another, lest an explosion or catastrophe happening to one of them should be fatal to the rest of the battery. To effect these objects :—

1. The guns are placed much further apart, and the merlons are consequently considerably thicker than in field-works.

2. The merlons are continued inwards (Fig. 62), so as to form a traverse between each gun. Every third merlon (*i.e.*, for each pair of guns) is made longer than the others, and contains a bomb-proof magazine and room for filling shells. The shells are delivered at the guns or near them through windows in these rooms; the charges of powder being served out in a separate room, and brought up from the end of the traverse.

3. The weak part of the embrasure is strengthened by a wrought-iron wall or shield, as high as the parapet, and of sufficient thickness to withstand direct fire. This shield is supported right and left of the gun by two large wrought-iron A-shaped brackets, and the gun fires through a porthole only just large enough to admit the muzzle and allow of aim being taken. The sides of the merlon inside the battery are reveted with masonry, and arrangements are made by which a temporary roof of iron girders, rails, earth, etc., can be constructed when an attack is expected. This roof is not absolutely necessary, but would doubtless afford protection from the splinters of shells, which burst high and over the front of the battery. Of course it must not be supposed that these details are to be found in exactly the order here described in many batteries, as the important items of expense and available space will generally be found to modify some of them.

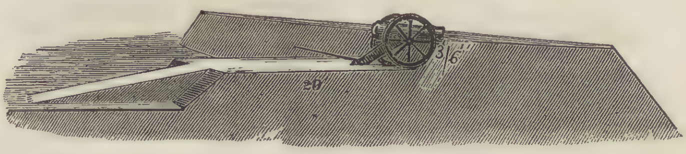


Fig. 67.—SECTION THROUGH AN ORDINARY BARBETTE OF A FIELD-WORK.

The general idea of the mode of placing guns on Moncrieff carriages behind parapets is shown in Fig. 66, and there is no doubt that it is admirably adapted to the circumstances of coast batteries, which have just been sketched out. It enables the gun to fire *en barbette,* and therefore, if mounted on a circular racer, it may follow a ship through any required arc, as is done in the case of guns mounted in a turret or cupola. As the gun is only visible above the parapet for a few seconds, it is not likely to be dismounted during that time by the necessarily somewhat random shooting of guns on such an unsteady platform as a ship's deck. The parapet behind which it works need not be of any great height above the ground level, or

afford a large target for the enemy to fire at. It therefore is a most useful and admirable invention, peculiarly applicable under certain circumstances; but it is not, however, so applicable, simple, and inexpensive, or so absolutely safe from fire as might at first sight be imagined. The carriage is of wrought iron, and necessarily strong and very heavy; this involves the necessity for a firm, well-built, permanent foundation. To protect the gun when in the loading position the height of the covering parapet above the platform or racer must be 10 or 11 feet, with a reveted interior slope; and this is only of use so long as the weak part of the parapet near the crest is not blown away, an event that would easily be accomplished by one or two large shells striking the superior slope, about 8 or 10 feet from the crest. It becomes necessary, therefore, to greatly strengthen this part by masonry, concrete, or iron, the latter being the only really reliable material, but enormously expensive. If the level of the crest is really made close to the ground line, and the gun works in what sounds so simple, a mere gun-pit, elaborate arrangements must be made for drainage of it, and for the magazines and shell rooms it requires, the floors of which would be far below the ground level. There can be no doubt that where the defence must depend on the action of a few powerful guns, they can best be rendered most formidable by being placed in a revolving iron turret, which is shot-proof, and consequently only liable to damage by some accident which prevents the turret from turning. These, however, are so expensive that they can only be employed in the most important cases; and in others, where the same results are wanted, but the money is not forthcoming, the Moncrieff system will undoubtedly often be a valuable substitute. The foregoing remarks apply only to the Moncrieff system as employed in coast and permanent batteries; for as no details of his scheme for field carriages have as yet been adopted in our service, the arrangements of the works to suit them are undeveloped.

NOTABLE INVENTIONS AND INVENTORS.

XXVI.—CHARLES BABBAGE, F.R.S. (*continued*).

BY JOHN TIMBS.

At length, in November, 1842, Mr. Babbage received a letter from the Chancellor of the Exchequer, stating that Sir Robert Peel and himself had jointly and very reluctantly come to the conclusion that it was the duty of the Government, on the ground of expense, to abandon the further construction of the difference engine. The same letter likewise contained a proposal to Mr. Babbage, on the part of the Government, that he should accept the whole of the drawings, together with the part of the engine already completed, as well as the materials in a state of preparation. This proposition he firmly declined. (Abridged from "Taylor's Scientific Memoirs," Vol. III., Part 12, the facts *from authority*.) The Government, however, abandoned the completion of the work. The late Lord Rosse, on leaving the chair of the Royal Society, entered a just protest, in the name of the leading *savants* of England, against the injudicious parsimony displayed by the Government in this matter. In June, 1843, the portion of the difference engine, as it existed, was placed in the Museum of King's College, Somerset House, His Royal Highness Prince Albert being present. "The portion of the engine was in order, and was capable of calculating to five figures, and two orders of differences, at the rate of twelve or fourteen arguments and corresponding tabular numbers per minute; and neither the number of orders of differences, nor the number of digits, would make any difference in its rate of work. Without numerous carefully lettered and figured mechanical drawings, it would be impossible to describe the elaborate mechanism of this engine; it has, indeed, been found impossible for one competent mechanic, who has fully mastered every portion, to explain the machine itself to another equally competent mechanic without the devotion of a considerable time." Such was the outline of the engine with which we were favoured by Mr. William Gravatt, F.R.S., in 1860, for our "Stories of Inventions and Discoveries," with an engraving of a small portion of the difference engine drawn by B. H. Babbage; the illustration being kindly afforded by Mr. Babbage, the inventor.

The following details are from the *Times*, Nov. 4, 1871:—"Mr. Babbage's achievements here were twofold; he constructed what he called a difference engine, and he planned and demonstrated the practicability of an analytical engine also. It is difficult, perhaps, to make the nature of such abstruse inventions at all clear to the popular and untechnical reader, since Dr. Lardner,* no unskilful hand at mechanical description, filled no less than twenty-five pages of the *Edinburgh Review* with but a partial account of its action, confessing that there were many features which it was hopeless to describe effectively without the aid of a mass of diagrams. All that can here be said of the machine is that the process of addition automatically performed is at the root of it. In nearly all tables of numbers there will be a law of order in the differences between each number and the next. For instance, in a column of square numbers—say, 9, 16, 25, 36, 49, 64, 81, etc.—the successive differences will be 7, 9, 11, 13, 15, 17, etc. These are differences of the first order. If, then, the process of differencing be repeated with those, we arrive at a remarkably simple series of numbers—to wit, 2, 2, 2, 2, etc. And into some such simple series most tables resolve themselves when they are analysed into orders of differences; an element—an atom, so to speak—is arrived at, from which by constant addition the numbers in the table may be formed. It was the function of Mr. Babbage's machine to perform this addition of differences by combinations of wheels acting upon each other in an order determined by a preliminary adjustment. This working by differences gave it the name of the difference engine."

It is worth while to recapitulate the progress of the engine. The Treasury, in 1823, granted Mr. Babbage £1,500 to make the machine, which was, from time to time, voted in payment for material and labour. Five years passed, and the Government grew anxious. Another committee of scientific men was appointed. Their verdict was, in effect, "Go on—give more money; the thing must answer." More money was advanced. In 1829 the Government had given £3,000, while £1,000 had been privately spent by Mr. Babbage on the machine. It was estimated that £1,000 more would complete the work; and of this sum, all but a few hundreds, was voted. In another year, another committee was appointed. Their report again expressed admiration, satisfaction, and reliance upon ultimate success, and advised the erection of a workshop close to Mr. Babbage's house, that the work might be hastened by his constant supervision. For this and the completion of the machine, from £8,000 to £12,000 was required; and this was to be in yearly sums of about a fourth of the amount. The building was erected, the work was recommenced in 1831 (when the total expenditure rose to £17,000), and came to a stoppage. This suspension was not fully explained at the time it took place; but the mystery in which it was shrouded has been thus explained in the "Dictionary of Universal Biography:"—"In spite of the favourable report of a commission appointed to inquire into the matter, the Government were led by two circumstances to hesitate about proceeding further. Firstly, Mr. Clements, the engineer or machinist employed as his *collaborateur*, suddenly withdrew all his skilled workmen from the work, and, what was worse, removed all the valuable tools which had been employed upon it." This act is justified as strictly legal by Mr. Weld, in his "History of the Royal Society," though the tools themselves had been made at the joint expense of Mr. Babbage and the Treasury. "Secondly," says the aforesaid authority, "the idea of the analytical engine—one that absorbed and contained as a small part of itself the difference engine—arose before

* Dr. Lardner, in a lecture delivered at the Royal Institution, May 2, 1834, gave the following outline of the engine:—"The front elevation will present seven upright columns, each consisting of eighteen cages of wheelwork, the mechanism in each cage being identically the same, and consisting of two parts, one capable of transmitting addition from the left to the right, and the other capable of transmitting the process of carrying upwards; for it appears that all calculations are, by this machinery, reduced to the process of addition. There will, therefore, be 136 repetitions of the same train of wheelwork, each acting upon the other, and the process of addition with the pen that would be going on successively from figure to figure, will here be performed simultaneously, and, as the mechanism cannot err, with unfailing accuracy. The results of this calculating mechanism are transferred by proper mechanical means to the printing machinery, their types are moved by wheelwork, and brought successively into proper position to leave their impressions on a plate of copper; which copper serves as a mould from which stereotyped plates, without limit, may be taken."

Mr. Babbage." Of course he could not help the fact that, in such matters, when one great victory was achieved, another and still greater battle remained to be faced and fought. But no sooner did Mr. Babbage, like an honest man, communicate the fact to the Government than the then Ministers, with Sir Robert Peel and Mr. H. Goulburn at the head of the Treasury, took alarm, and, scared at the prospect of untold expenses before them, resolved to abandon the enterprise. Mr. Babbage, apart from all help of any kind whatever from the public purse, had spent upon his machine, as a pet hobby, no small part of his private fortune—a sum which has been variously estimated between £6,000 and £17,000. (*Times.*)

A contemporary, in a glance at the merits of Mr. Babbage's great invention, remarks: "The science of numbers, to which he devoted his days, could never, from the very nature of the case, be made popular. Arithmetical calculations must necessarily be uninteresting to the multitude, but when people were told that a machine had been invented for working out these calculations by means of wheels, or watchwork, the idea was at once comprehensible and marvellous. In reality, 'Babbage's machine' scarcely admits of simple and popular description, but the mere fact that inanimate metal could be made to perform the subtle work of man's brain came home to the public mind as a thing to be remembered for ever. There was truth, too, in the story. Though Mr. Babbage's instrument was repudiated by the Treasury, the idea of such a machine in a more manageable form has since been turned to account, and utilised in Government offices."

From reading the account of the difference engine in the *Edinburgh Review*, Mr. George Scheutz, then editor of a technological journal in Stockholm, was so fascinated with the subject, that he set about constructing a machine for the same purpose as that of Mr. Babbage—namely, that of calculating and simultaneously printing numerical tables; but, after satisfying himself of the practicability of the scheme, and constructing models, he relinquished the design. Next, his son, Mr. Edward Scheutz, being provided with a work-room in his father's house, as well as a lathe, and other tools, constructed a working model in metal. The father now applied to the Swedish Government for aid, but was refused. The father and the son then worked together, until, becoming exhausted by sacrifices for the purchase of materials and tools, yet convinced that with better workmanship a more perfect instrument was within their reach, they again applied for assistance to the Diet of Sweden. The conditions, however, on which the Diet consented to advance about £280 were so stringent that the Messrs. Scheutz renounced the work, and the model remained shut up in its case during seven years. They then obtained a pittance from the Diet, and after working day and night, completed the machine, when the Swedish Government rewarded the inventors with £280. The new engine performed its work perfectly, and in 1854 the inventors brought their machine to London, where Mr. Gravatt explained it to the Royal Society, and next to the Great Exhibition in Paris, where a jury unanimously awarded to it a gold medal. "The Emperor Napoleon," says Mr. Babbage, "true to the inspirations of his own genius, and to the policy of his dynasty, caused the Swedish engine to be deposited in the Imperial Observatory at Paris, and to be placed at the disposal of the Board of Longitude." In 1856, Mr. E. Scheutz brought the machine from Paris to London, where it was set to work in an apartment of Mr. Gravatt's house, in Westminster. In 1856, Mr. Babbage, in some observations which he addressed to the Royal Society, explained that the adding part was entirely different from his own, as well as the mechanism for carrying the tens; and that the printing part was altogether unlike. The contrivance by which the computed results are conveyed to the printing apparatus is the same in both engines, being that known as "the snail" in the striking part of the common eight-day clock. One of Scheutz' difference engines, made by Messrs. Donkin for the English Government, is (we believe) now worked in the Registrar-General's Office in Somerset House.

Of the analytical machine, the properly qualified mathematician will find and appreciate a paper by General Menabrea, of Turin, translated by the accomplished Lady Lovelace, daughter of Lord Byron: "the profound, luminous, and elegant notes forming the larger and by far the most instructive part of the work, and signed A. A. L., are all by that lamented lady." (*Gravatt.*) "We have heard Mr. Babbage say that he could construct a machine on the principles of his analytical engine, which should play and win a game of chess."—*Athenæum.*

Many years age, Mr. Babbage printed and circulated suggestions for "Constants of Nature and Art," to form a great collection of facts which can be expressed by numbers, in the various sciences and arts. In 1855 he proposed a method of laying the guns of a battery without exposing the men to the fire of the enemy; and in the same year he suggested the application of occulting lights to military operations conducted in the night.

Mr. Babbage expired on the 20th of October, 1871, being nearly eighty years of age. He was one of the oldest members of the Royal Society at the time of his death. He was one of the only survivors of the founders of the Astronomical Society of London; and the only survivor of the founders of the Statistical Society of London, the meetings of which he attended to the last. Throughout his long life, he bore his defeats and disappointments from all quarters with true philosophy, save in some cases of vulgar annoyance. But he was, as our own experience proved, a man of generous nature, loving to indulge in kindly offices, and widely esteemed for qualities beyond his brilliant scientific renown.

CIVIL ENGINEERING.—XV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS (*continued*).

The material of which the breakwater at Portland is constructed is, as might be supposed, mainly derived from the adjacent quarries on the island. The stone is oolite, abounding in fossils, and admirably adapted for the purpose. The mode of working the stone in the quarries is peculiar to the place. The stone lies in beds nearly parallel with the surface of the land. The beds vary in thickness from 2 to 4 feet and upwards, and are covered with a stratum termed, locally, a "cap." The capping is formed of shells in a fossil state, the ammonites being of great size; it is very hard, and is usually detached by blasting. After the cap is removed the quarrymen proceed to cross-cut the large flats which are laid bare with wedges, and split it off in masses. The blocks so split off are by no means even in surface, and the men reduce it to something of a regular shape with a tool called a "kevel," which is at one end a hammer and at the other an axe, having a short and narrow edge like a pick. The face of the hammer is not quite flat, but slightly hollowed out, by which means a rather sharper edge is secured; and it is surprising with what facility the stone is worked with this tool, and what large masses, called "spawls" or "shivers," are brought off at each stroke. The stone employed in the construction of the breakwater was wholly wrought by convict labour obtained from the prison situated on the island. It was brought down to the work by a series of three inclined planes furnished with rails, and worked in the usual manner by ropes passing over drums, having powerful breaks fixed to them. The loaded wagons in their descent draw up the empty ones. This very usual method of conveying heavy material from a higher to a lower level is by far the most economical plan that can be adopted. It is, of course, only applicable in those localities where the work to be carried out lies at the bottom of the incline, and the source of supply at the top. The actual dead weight of any load upon an incline, setting aside friction, may be represented by the fraction $\frac{n \,.\, 2240}{\text{rate of gradient}}$, the quotient being in pounds per ton. Thus, if a loaded truck weigh 8 tons, its dead weight, friction excluded, upon an incline of 1 in 20 will be $\frac{2240 \times 8}{20}$ lb.=896 lb. Again, suppose the empty truck upon a similar incline to weigh 1 ton; then *its* dead weight, friction excluded, will be $\frac{2240 \times 1}{20}$ lb. = 112 lb. Now, if we consider the friction due to the trucks and the rollers over which the rope passes, as equivalent to 20 per cent. of the load, we obtain as the effective dead weight of the descending load $896 - 112 + \frac{112 + 896}{5} = 583$ lb., which represents the entire force to be overcome by break power in lowering a load of 8 tons down such an incline.

Of course, many inclined planes are greatly steeper than 1 in 20, in which case the power to be overcome will be proportionately increased, because the divisor becomes smaller and the friction less. Still it is obvious that where gravity is the motive force employed, and the mechanical arrangement of the break is good, it becomes an exceedingly efficient and inexpensive method of conveying the material to the work.

At Portland, as soon as the loaded trucks arrive at the level of the work, they are transported by locomotive engines running upon rails, supported by timber stages resting upon piles driven 30 feet apart, and standing 18 feet above high water. The piles are in two pieces, made of timber 15 inches square, scarfed and bolted together. The bottoms terminate in a cast-iron shoe fitted with a Mitchell's patent screw. The entire piles are from 60 feet to 90 feet long, and are forced from 4 to 5 feet into the ground by powerful capstans. The spread of the screw prevents any great settlement into the soil, notwithstanding the weight of the engines and the loaded wagons continually passing over them. One form of screw-pile is shown in Fig. 36. The *spread* from A to B varies with the requirements of the case from 1 to 4 feet. We shall have another occasion to refer to the use of these important instruments.

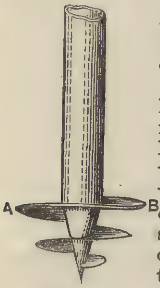


Fig. 36.

By means of five lines of rails—the number laid down on the Portland Breakwater—as much as 2,200 tons of materials can be delivered daily. The "tipping" or discharge of the rubble is accomplished by means of a wooden cam or stud fixed to the rails at the desired point. A lever attached to the under side of the wagon strikes this in passing, and detaches the key which retains the bottom of the wagon in its place; this turns upon a pivot, and the momentum acquired by the wagon causes it to "cant" when suddenly arrested in its progress, and thus empties itself of its load. The inside end is the heavier; as soon, therefore, as the load is discharged, the pivoted portion recovers its horizontal position. As the work progresses the cam is moved further on. The wagons are of wrought iron, and can load seven tons of stone. The weight of the stone in the solid block averages 16 feet cube to the ton, and when deposited in the base of the work as *pierre perdue* occupies from 20 to 21 feet cube of space.

The slope on the sea front is 5·5 to 1. The pier-heads are circular, 100 feet in diameter, cased with vertical walls of solid masonry 22 feet thick at base, and 12 feet thick at top. The interior space is filled in solidly with rubble, and grouted. The heads are built upon a foundation of rubble brought up to within 24 feet of low water, surmounted by a coursing of Yorkshire stone 12 inches thick, which covers the entire horizontal face of the rubble. The vertical walls have an exterior casing of granite laid in courses 5 feet wide and 3 feet thick, backed with Portland stone, the whole being bonded and dowelled together, vertically and horizontally. The blocks are set by means of travelling cranes working upon the upper stages, and regulated in their position beneath the water by divers.

The advantages arising from the open space which has been left in this long line of breakwater are very apparent; for, whilst the pressure of water resulting from a difference of level upon one side or the other, according as to whether the tide is ebbing or flowing, is effectually reduced by the water-way thus afforded, any waves which may enter produce only a very slight and immaterial effect upon the enlarged space of the roadstead within.

A few particulars respecting the harbour at Ramsgate, which is formed by enclosing a space of exposed water by piers or breakwaters, may not be uninteresting. The dangerous character of the coast in this vicinity, and the large amount of shipping which frequents this part of the Channel, rendered the construction of a harbour of refuge at this point a matter of absolute necessity. Even in the reign of Edward VI. an attempt was made to construct a harbour between Sandwich and Sandown Castle. This harbour consisted of a canal, traces of which yet remain. In 1574 Elizabeth appointed a commission to inquire into the subject, and in 1706 a plan was made for a harbour between Sandwich and the Downs. The proposal for a canal at Sandwich was revived in 1737, the former one having become useless. Smeaton always advocated Ramsgate as the most suitable locality for a harbour, the long stretch of coast between Newhaven and the North Foreland affording no natural break which could be turned to practical account as such. If, therefore, a harbour were to be formed between these points, it could only be by the projection of piers or breakwaters into the Channel to a distance sufficient to ensure a suitable depth of water at the entrance at certain periods of tide.

For many years previous to the period when Smeaton's advice was sought in 1774, a small haven had existed at Ramsgate, suitable, however, only for fishing-boats; and indeed so early as 1750 an extension of this harbour had been commenced by the projection of two curved arms or breakwaters, but the great and persistent silting up of the entrance by sand rendered it of little practical value. These extensions continued to advance for twenty years, and consisted of a wooden pier upon the west side and a stone pier upon the east side, each having been designed and carried out by separate engineers, or rather amateurs. After a course nearly due south, these piers gradually bend towards each other, until a contracted entrance is formed having a bearing slightly to the west of south, with an overlap upon the east side. The serious difficulty arising from the accumulation of sand within the harbour was overcome by the genius of Smeaton, who found that the sand entered with every tide, and became deposited in the still water within the piers. He therefore constructed an artificial back-water—there being no land-water available—which could be retained by sluices until the favourable period for releasing it had arrived; this had the effect of scouring the outer basin and freeing it in an effectual manner from deposit. Indeed, so powerful was the action of the scour upon the bottom, that the foundation of the piers became endangered by the removal of the chalk upon which they were built. To obviate this danger Smeaton constructed a stone apron of four courses around the east pier head and wherever protection was required, the basement course being 18 feet wide, the second 16 feet, the third 14 feet, and the upper course 12 feet, and extending vertically to within 7 feet of low-water spring tides. The depth of water at which these courses were to be laid proved an obstacle, and to facilitate the work Smeaton introduced for the first time the diving-bell, that most important adjunct to marine engineering operations, which has since then become of such constant use. The bell employed by Smeaton at Ramsgate Harbour consisted of a rectangular chest of iron weighing 50 cwt., and of sufficient weight to sink itself. It was 4 feet 6 inches high, 4 feet 6 inches long, and 3 feet wide, being large enough for two men to work in. It was supplied with a constant influx of fresh air by means of an air-pump placed in a boat near at hand. It is of interest to record the very day when the first and successful trial of this machine was made—July 7th, 1788.

The harbour as now completed contains an area of forty-two acres, the piers extending 1,310 feet into the sea. The entrance has a width of 200 feet, and possesses a depth of water at the pier-heads of 19 feet at high-water of spring-tides, and 16 feet at neaps.

The *position* of a breakwater is a point requiring very great forethought and investigation on the part of the engineer. It is at all times an expensive structure, and it therefore becomes desirable to place it where the greatest possible benefit shall be derived from it. Every stone must, in fact, be utilised to the utmost. The general character of its construction may be gathered from the foregoing remarks, and it may be assumed that that system which has proved efficient and durable in more exposed situations, will be equally durable in other localities. Nothing appears to form so substantial and so economical a base for a breakwater as large rough blocks of stone thrown down from the surface along the intended line of the breakwater. The slope will thus assume a natural angle, which the wash of the waves will eventually consolidate in character. It must, however, be borne in mind that in any calculation of *quantity* required for a base, the *natural* talus will vary with the size of the component parts. Thus we find that a *sandy* shore assumes by the natural action of the sea a position nearly *horizontal;* a pebbly beach presents a greater slope to the water; large boulders a still steeper front; and the solid rock stands with an almost vertical face exposed to the waves.

The set of the tides, the velocity and direction of currents, the prevailing winds, any local advantages arising from projecting

headlands, isolated rocks, and so forth, must be carefully considered; and, above all, the utmost facility afforded for vessels driven by stress of weather to avail themselves of the security afforded by the breakwater. The necessity for beacons, to enable vessels to make the entrance, and to avoid stranding upon that which is intended for their benefit, is a point which scarcely need be insisted upon. The character of such beacons will be considered in its proper place.

Hitherto our remarks have been confined to *fixed* breakwaters, that is, those which rest upon the solid bottom. But there is another class of breakwater to be considered, and one about which considerable difference of opinion exists; we allude to *floating* breakwaters.

Most of our readers are aware of the fact that when a small boat desires to communicate with a large ship riding at anchor in rough water, it always seeks to do so if possible upon what is termed the *lee*-side of the ship, that is, upon the side *opposite* to that on which the wind strikes, and the reason for doing this is, because there exists a very perceptible difference in the state of the water upon the two sides, the lee-side being very much smoother. Now the reason of this difference is simply due to the fact that the large vessel, although itself floating, and to a certain extent influenced by the waves, has acted as a breakwater. It is not difficult to suppose that a fact so obvious should have raised the idea of employing old hulks, or floating structures specially designed for the purpose, and moored in a continuous line across the mouth of the port or harbour requiring protection, for this specific purpose. Those who advocate the system urge its superior economy over a regularly-built structure, and the facility with which any one of its constituent parts can be removed for repairs, or replaced, and there can be no doubt that in both these respects it has its advantages. On the other hand, it is evident that inasmuch as the stability of each portion is dependent upon the mere strength and holding power of the mooring arrangements, it is possible that such a storm might occur as would render any such arrangements unable to cope with its fury, and that then, at the very period when its value as a shelter would be the greatest, it would cease to be of use, and the ships which had been driven from the storm without to seek safety within would, being land-locked, be in a far worse position than had they never sought its shelter. And again, it may be urged that, granted the cables and anchors did their duty and withstood all the force of the wind and water, yet the shelter afforded is after all only a partial shelter, for the larger waves by which the breakwater itself is influenced will inevitably pass beyond it and enter the port, producing disturbance and commotion amongst the shipping; for it may be taken as an acknowledged fact that *nothing* will break and expend the fury of an advancing wave more surely than a sloping shore; even a solid wall or rock, if its face is vertical, will permit the wave which rolls against it to recoil and pass on elsewhere, diminished slightly, it is true, in altitude, but still powerful for mischief.

With respect, therefore, to floating breakwaters, we are confined to this fact, that only a certain amount of benefit can result from their use. The larger the floating structure the better, provided the size is thrown in the right direction. Arguing from the fact that an *immovable* structure will prevent the passage of a wave, it is evident that the less easily a floating structure is influenced by the wave, the more shelter will it afford. What, then, should be the form or character of the structure? If this question can be satisfactorily settled, we may yet hope to gain some advantage from the use of floating breakwaters. Now, that peculiar characteristic of floating bodies which we term "buoyancy" is not strictly the same as its power of floating. Its use is rather to be restricted to bodies whose shape or material renders it very readily moved *vertically* by a passing wave. A cork is in this respect strictly buoyant, and it is buoyant because its *material* is buoyant. A broad thin dish of iron is also buoyant, but this is buoyant because of its *shape;* or because the surface resting upon the water is large in proportion to its absolute weight. But it will be possible to shape a vessel out of an equal mass of iron, so that although it shall float, it shall not be buoyant in the sense we speak of. By reducing the base and throwing the metal into the sides—the *thickness* remaining the same in either case—we shall obtain a vessel which will be far less readily influenced by a passing wave than the shallow dish would be. Here, then, we have the key to the form of structure best suited to stop the progress of a wave. Neither is it difficult to prove the truth of our statement. Let us assume a mass of material—iron for instance—of a given weight. Then let it be shaped into a vessel of such a shape as that its line of floatation shall be one-quarter its height. Again, let an equal weight of iron be so shaped as that its line of floatation is three-quarters its height. Now, if the iron employed be of equal thickness in either case, the difference in the height of the floating line can be obtained only by reducing the maximum horizontal section below the line of floatation, in this case to one-third, and the effect of this reduction will be to diminish the vertical effect of a passing wave upon the body, in this instance by two-thirds, because the pressure exerted by water—other things being equal—is in every direction directly proportional to the surface acted upon.

It follows from this that, in the case before us, a wave of three feet vertical height will produce no greater effect upon the deeper floating vessel than a wave of one foot vertical height will upon the shallow vessel, and consequently its altitude or effect upon the opposite side will be proportionately diminished. It would, perhaps, not be too much to assert that the greatest beneficial effect would result from a screen or wall of iron-plate standing vertically in the water, the lower end nearly touching the soil at low-water springs, and the upper end buoyed by means of casks or other appliances fixed on the *inside* of the plate, the whole being strongly secured by chains to efficient moorings. In order to present a less obstructive face to the waves such a structure might be curved slightly inwards at the upper part.

The theoretical effect of such an arrangement would be almost entirely to stop the progress of an advancing wave, because, whilst the whole mass would rise and fall by the action of the long tidal wave, the more sudden rise of an ordinary wave would be felt only upon the outer face, and would not act upon the buoyant portion on the inside.

Still, when it is remembered that the force of a wave will hurl before it a mass of solid rock of many tons weight, the almost utter hopelessness of securing against the attacks of the sea a wall of iron of an extent sufficiently great to be of practical utility as a breakwater, becomes apparent.

Upon the whole, therefore, we incline to the opinion that floating breakwaters are amongst those achievements of engineering which, although by no means impossible, and undoubtedly desirable, have yet to be accomplished.

TECHNICAL DRAWING.—LXI.

GOTHIC STONEWORK.

GLOSSARY (*concluded*).

BRACKET—An ornamental projection from the face of a wall to support a statue, etc. Brackets are sometimes nearly plain, or ornamented only with mouldings, but are generally carved either into heads, foliage, angels, or animals. They are very frequently found on the walls in the inside of churches, especially at the east end of the chancel and aisles, where they supported statues which were placed near the altars.

CATHEDRAL—The principal church where the Bishop has his seat (*cathedra*) as diocesan. It is so called in contradistinction to *abbey* or *priory* (see these), which may be churches of equal or greater size or importance, but are not presided over by a bishop. It is said no town can correctly be called a *city* unless there be a cathedral therein.

FRITHSTOOL, or FREEDSTOOL—Literally, "the seat of peace" (German, *fried-stuhl,* "peace-chair"). A seat or chair placed near the altar in some churches, the last and most sacred refuge for those who claimed the privilege of sanctuary within them, and for the violation of which the severest punishment was decreed. They were frequently if not always of stone.

GALILEE—A species of porch where, it has been said, the female relatives of the monks went to confer with them, they not being permitted to enter the conventual buildings.

GARGOYLE, or GURGOYLE—Carved terminations to the spouts which conveyed away the water from the gutters, and are supposed to be called so from the gurgling noise made by the water passing through them. Sometimes they are perfectly plain, but are oftener carved into figures or animals which are

frequently grotesque; these are very commonly represented with open mouths, from which the water issues; but in many cases it is conveyed through a leaden spout, either above or below the stone figure.

GRILLE—The ironwork forming the enclosure screen to a chapel, or the protecting railing to a tomb or shrine. Grilles are more common in France than in England.

GROIN—The angle formed by an intersection of vaults. Most of the vaulted ceilings of the buildings of the Middle Ages are groined, and therefore called groined vaults, or groined ceilings. During the earlier part of the Norman style the groins were left perfectly plain, but afterwards they were invariably covered with ribs.

HAMMER-BEAM—A beam very frequently used in the principal timbers of Gothic roofs to strengthen the framing, and to diminish the lateral pressure that falls upon the walls. Each principal has two hammer-beams, which occupy the situation of a tie-beam, and in some degree serve the same purpose; but they do not extend across the whole width of the roof. The ends of hammer-beams are often ornamented with heads, shields, or foliage, and sometimes with figures.

LANTERN—A turret raised above a roof or tower, and very much pierced, the better to transmit light. In modern practice this term is generally applied to any raised part in a roof or ceiling, containing vertical windows but covered in horizontally.

LICH-GATE—A covered gate at the entrance of a cemetery, under the shelter of which the mourners rested with the corpse while the procession of the clergy came to meet them.

MISERERE—Seats in the stalls of large churches, made to turn up and afford support to a person in a position between sitting and standing. The underside is generally carved with some ornament, and very often with strange, grotesque figures and caricatures.

PISCINÆ—Hollows or niches near the altars, with drains to take away the water used in the ablutions at the Mass. They seem at first to have been mere cups or small basins, supported on perforated stems placed close to the wall, and afterwards to have been recessed therein and covered with niche-heads, which often contain shelves to serve as ambries. They were rare in England till the thirteenth century; but there is scarcely an altar of later date without one. They frequently take the form of a double niche with a shaft between the arched heads, which are often filled with tracery of an elaborate character.

POPPY-HEADS—The finials or other ornaments which terminate the tops of bench-heads, either to pews or stalls. They are sometimes small human figures or heads; sometimes richly-carved groups, images, knots of foliage, or finials, and sometimes fleurs-de-lys, simply cut out of the thickness of the bench-end and chamfered.

PRIORY—A monastic establishment, generally in connection with an abbey, and presided over by a prior, who was a subordinate to the abbot. (See ABBEY.)

REFECTORY—The dining-hall of a convent, monastery, college, etc. The internal arrangements and fittings were very similar to those of the ordinary domestic halls, except that it was usually provided with a raised desk or pulpit, from which, on some occasions, one of the inmates of the establishment read to the others during meal-time.

REREDOS—The screen or other ornamental work at the back of an altar.

SACRISTY—A small chamber attached to churches, where the chalices, vestments, books, etc., were kept by the officer called the Sacristan.

SEDILIA—The seats near the altar in churches, used by the priest and officiating clergy during certain portions of the communion service. They are generally three in number.

TABERNACLE—A species of niche or recess in which an image may be placed.

TABERNACLE-WORK—The rich ornamental tracery forming the canopy, etc., to a tabernacle. It is common in the stalls and screens of cathedrals; and in them is generally open or pierced through.

TYMPANUM—The triangular space between the horizontal and sloping cornices on the front of a pediment in Classical architecture. It is often left plain, but is sometimes covered with sculpture. This name is also given to the space immediately above the opening of a doorway, etc., in mediæval architecture, when the top of the opening is square and has an arch over it. This arrangement is not uncommon in this country in Norman work, and on the Continent is to be found in each of the styles. This kind of tympanum is occasionally perfectly plain, but is generally ornamented with carving or sculpture. In Continental work the subjects are usually arranged in tiers one above another, and often embrace a great number of figures. Also when an arch is surmounted by a gable-moulding or triangular hood-mould, the space included between the arch and the triangular hood-mould is termed the tympanum of the gable.

PRACTICAL APPLICATION OF THE FINE ARTS.—IX.

THE ART OF MOSAIC.

By P. H. DELAMOTTE, Professor of Drawing, King's College, London.

BY mosaic we understand the art of putting together pieces of various materials, either white or particoloured, in such a way as to form definite patterns. Just as a musical note differs from a mere sound by the fact that there is a certain rhythmical arrangement of pulsation instead of vibration repeated at no certain interval, so does a mosaic pavement, for instance, differ from an ordinary pavement, in having the materials arranged in a certain order, according to their shape or colour. We do not wish to imply that pavement is the only purpose to which mosaic can be applied, but it gives the readiest means of explaining what we mean by mosaic, and it appears to have been the earliest purpose to which mosaic was applied. Pavement was that kind of flooring formed by the pavior by striking or beating, as the word implies, the materials into a firmer consistency than the mere stone and concrete would otherwise take. Mosaic is essentially an architectural art; whether it be applied to ornamentation of pavements, to the facing of walls, or the copying of pictures, or the decoration of furniture. The small scraps of Roman work that are inserted in jewellery are mere toys, simply imitating that which is the real art.

The origin of the art, like that of many others of far more importance to the well-being and the culture of man, is lost in obscurity, and yet we can trace it far enough to feel sure that it must have arisen amid the early civilisation of the great empires of Western Asia. The same word which Ezekiel uses to describe the pavement as seen by him in his visions of the new temple, and which no doubt he idealised from the actual pavements in Assyria, is used also of a pavement upon which Ahaz, the King of Judah, who copied, at least, Assyrian altars, placed the "sea" when he had removed it off the brazen oxen; and is also employed in the book of Chronicles to designate the floor of the court in which the Israelites assembled at the dedication of the temple in the reign of Solomon. Amid the remains of Nineveh now deposited in the British Museum, there are floors of stone or alabaster cut into patterns. After the destruction of Nineveh we find in Persia, at Shushan (Susa), that Ahasuerus, according to the book of Esther, made a feast "in the court of the garden of the king's palace," and after the description of other decorations, it continues, "Upon a pavement of red, and blue, and white, and black marble." These latter words are translated by some modern scholars to mean alabaster, white marble, mother-of-pearl, and red marble. The mother-of-pearl we should think must be a material of doubtful advantage in any surface which had to undergo the wear and tear of much traffic; perhaps in the court of the garden of a king's palace endurance might have been willingly sacrificed to beauty of appearance. The whole account reads so like some of the drinking scenes portrayed in the Ninevitish sculpture, and especially one in which a king is represented as drinking with his queen, he reclining in a couch, and she sitting laughing in a straight-backed chair in a "court of a garden," with vines trellised around, that we cannot but think that the Persians took some of their decorations from their predecessors in dominion. We know that the Greeks, who took the origin of all their arts from Asia or from Egypt, and so improved upon the stagnant and Oriental character of each that they handed them down to their successors in forms scarcely to be recognised as belonging to the original model, made use of this style of decoration in their noblest buildings. Unfortunately, none of their works

remain to us, but as Greece disappeared her treasures were swept into the all-gathering net of Rome; and mosaic begins to flourish in Italy just when the old Romans advance to the study of Grecian art, and language, and philosophy. The subjugation of Greece brought many Greek artists to Italy, and some of their work remains to testify to the fact. The oldest Roman name for mosaic is *lithostrotum* (λιθοστρωτὸν), a word showing, as words so often do, by its Greek derivation, that the origin of the art as far as the Romans were concerned, was Greek. It was on such a *lithostrotum* that Pilate from his judgment-seat delivered over the rejected Jewish king to be crucified as a slave might have been.

The oldest piece of mosaic known to exist is that at Palestrina, formerly Præneste, near Rome, where it was placed in the Temple of Fortune by Sulla, B.C. 80; but the Greek workmen left the inscription on it in their native Greek character. From that day to this the art has been principally cultivated by the Italians. Wherever the Roman arms extended their sway, there their soldiers carried with them the luxuries they were accustomed to at home, hence Gaul and Britain contain many remains of this their work; and their descendants to the present day in Rome itself, in Florence, and in Venice, have excelled and do excel in different branches of this same art.

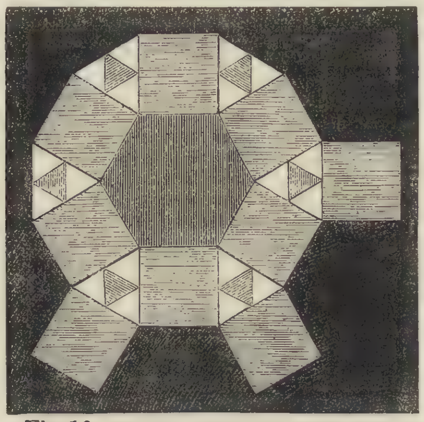


Fig. 16.—OPUS SECTILE IN CHURCH OF S. CROCE IN GERUSALEMME, AT ROME.

The name for mosaic amongst the Romans we have noticed was of Greek origin—all the names for the different varieties of mosaic, and these were numerous, were of native growth. In the first place we have the *opus tessellatum*, whence we derive our phrase of tesselated pavement. This takes its name from the *tessellæ* or *tesseræ*, the technical name for the small cubes or pieces of which the pavement is formed. In the *opus tessellatum*, the tesseræ were small cubes or square dies of about three-quarters of an inch square, sawn or worked by the hand into proper shape, and then arranged in geometrical patterns. The colours first employed are supposed to have been black and white, but at a later period other colours came into use, as they were found advantageous in other kind of mosaic, and had been employed in the species called *opus figlinum*, which will be described afterwards. The same kind of tesseræ were used also in other sorts of mosaic, but it was not called *tessellatum*, unless the component parts were exclusively of this square shape. There are many specimens of this work in various parts of this country, as for instance at Claxby, in Lincolnshire (where the colours are blue, white, and black), in many of those pavements discovered beneath the city of London, in the borders of the finer floorings and in the smaller passages of many of the Roman villas discovered in various parts of this country. The finest specimens no doubt are to be found in Italy, in the excavations of Herculaneum and Pompeii, in the Sala of Nuovo Braccio in the Vatican, and especially in the Baths of Caracalla, at Rome.

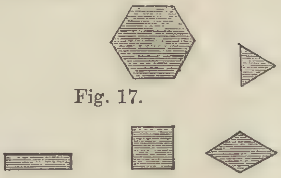


Fig. 17.

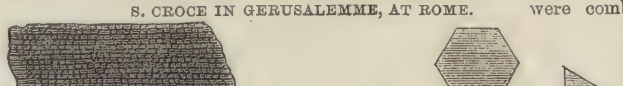


Fig. 26.—FROM THREADNEEDLE STREET, LONDON.

The *opus sectile* is called after the *secta*, or portions cut out from the coloured marbles or *crustæ*. In this work the marbles were divided into various shapes—triangles, squares, oblongs, rhomboids, hexagons, etc., as in Fig. 17. These are combined so as to compose regular geometrical figures of more or less intricacy, but in no case is an attempt made to imitate any natural object. The materials used are very various. In a pavement in the church of S. Croce in Gerusalemme, at Rome, a pattern is formed of hexagons of *pavonazzetto* (a purple stone), surrounded with squares of red porphyry, the intermediate equiangular triangles being composed of four smaller triangles, three of palombino, and one of serpentine, Fig. 16. This species of work is never found in this country, and it is not common in Italy. The earliest date assigned to it is B.C. 100. In the Pantheon at Rome and in St. Peter's may be seen the finest examples.

The *opus figlinum* or *figulinum* differed from the former in several particulars—in material, in pattern, and in employment. Whereas the former sorts of mosaic were composed of marbles and natural stones, in this work a species of encaustic tile or terra-cotta, sometimes called "ceramic tesseræ," was employed, hence it was called *figulinum*, from *figulus* (a potter, or maker of fictile ware). These were more or less of a vitreous composition, formed principally from alumina, but having various colours produced in them by the addition of metallic oxides. Sometimes these tesseræ were combined with natural marbles, alabaster, etc., and in these works do we find for the first time gold introduced. This was employed in somewhat of the same manner as it was in later times, and is still used in Venetian mosaics. On a thick groundwork of the vitreous compound, in shape like a thin tile sunburnt (and thus Salviati and Co. employ various deeply-coloured glasses to give a different tone to the slightly transparent gold) a piece of gold-leaf is laid; upon this again a thin coating of transparent glass is placed, and the whole transferred to a kiln and burnt much in the way in which stained glass is burnt after it is painted. The main difficulty, of course, is to know when the tile has been submitted to sufficient heat to vitrify the material without giving it sufficient liquidity to allow the gold to run into masses. The whole should become homogeneous, and the union of parts should be perfect, but it should not run. Besides being different in material, the *opus figlinum* differs also in pattern. We have now introduced imitations of natural objects, leaves, fruits, and figures. The effect of this, of course, was soon visible upon other kinds of mosaic, and we not unfrequently find mosaics—formed wholly or in great part of marble and natural stone—which portray men and animals, as well as flowers and fruit, though this rather belongs to the next kind that we shall describe; but we, too, may note that none of these designs appear earlier than the invention of the *opus figlinum* which, Pliny states, was made B.C. 24. The use, too, of this species of mosaic was different from that which we have described before. The former kinds were employed almost exclusively for pavements; but with the new material and new designs mosaic began to be used for walls, for ceilings, and even for the

decoration of furniture. The Baths of Agrippa afford one of the best examples of the ancient form of this beautiful kind of work.

But the most important of the ancient mosaics was the *opus vermiculatum*, which was formed of tesseræ of irregular shapes or sizes, varying from half an inch square to one-twentieth of an inch. The pieces were individually adapted to their position, so that they might follow the lines of the design, and thus in the background or in large spaces of even colouring these divisions caused an appearance like a mass of worms wriggling, hence the name *vermiculatum*, from *vermes* (a worm). In this work naturally the artist employed whatever material would give him the desired colour and shade, and though marble was probably preferred, this was supplemented by fictile work. In a quantity of mosaic work found on the site of a Roman villa at Cirencester, the materials employed were principally freestone, oolite, sandstone, limestone lias of various colours (and some of these had been altered by heat), and a little chalk; some colours, especially reds and blacks, were of terra-cotta, and in one case a bright red was produced by a ruby glass. The colouring matter in this latter case was an oxide of copper. During the long period of burial beneath the earth, the surface of the coloured glass had decomposed into verdigris and silica, leaving an appearance of a bright green; as this bright green came in masses in the midst of a duller green representing leaves, it gave an appearance of very dull colouring, until it suggested itself to Professor Buckman, to scrape off the green and the dull white beneath it, and thus to discover the bright red below. Thus we see that the Romans employed whatever material came to hand—in the *opus figlinum*, they used exclusively terra-cotta or a kind of glass; in the *vermiculatum* they brought in marbles of all colours, alabaster, commoner sorts of stone, sandstone, freestone, etc., and even chalk, and the colours not readily producible by this means they produced by means of tiles and glass.

Fig. 19.—FROM WOODMANCHESTER, GLOUCESTERSHIRE.

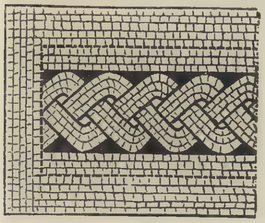


Fig. 22.—FROM CIRENCESTER.

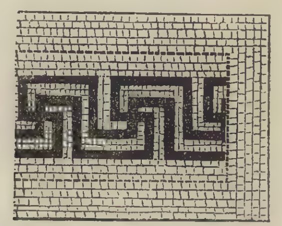


Fig. 23.—FROM CIRENCESTER.

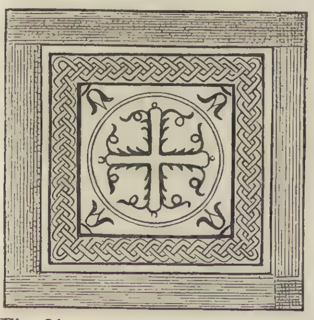


Fig. 21.—FROM BANK OF ENGLAND.

Fig. 18.—FROM BATHS OF AGRIPPA.

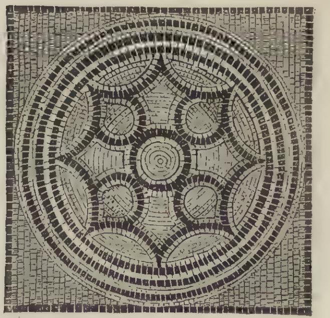


Fig. 20.—FROM ABBOTS ANN, HANTS.

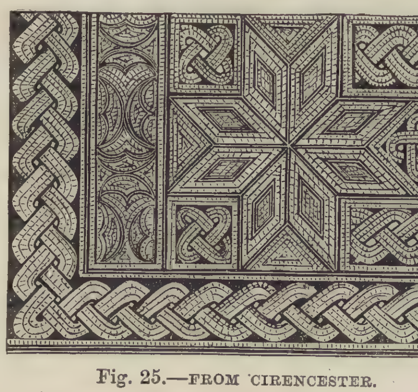


Fig. 25.—FROM CIRENCESTER.

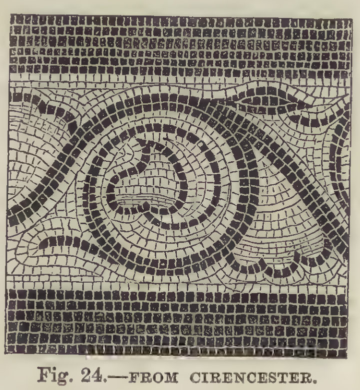


Fig. 24.—FROM CIRENCESTER.

There are three recognised classes of the *opus vermiculatum*. The *majus*, which is applied to pavements or ceilings, and is commonly of only black and white marble. In this material figures are produced which, though somewhat coarsely drawn, are very effective, and exceedingly spirited. There are good examples of this in England, but the most striking perhaps are to be found in the Baths of Caracalla, at Rome. The second

kind is called *medium*, and is employed in the decoration of walls. The character of the designs is principally festoons of flowers, and figures of cupids and nymphs. Naturally, from the position of this work, it is more likely to perish as the wall decays than when placed as a pavement, when it merely gets covered over, and, dropping out of sight, is preserved by that which hides it. The wall, on the other hand, falls, breaks as it drops, and the mosaic crumbles into a mere handful of curiously-chipped pebbles. There are, however, some remains of this *medium* work in the Vatican and in the Museo Borbonico at Naples brought from the neighbourhood of Pompeii; besides minor specimens, there is the well-known representation of the contest of Alexander and Darius, at the battle of Issus. This, perhaps, is the finest example of the ancient Roman mosaic work known to exist; for though we know that no Roman of the upper classes thought his house complete without decoration of this kind, the houses themselves have so completely disappeared in the course of sixteen or seventeen centuries that but very few specimens remain to us.

The third kind of *opus vermiculatum* was called *minus*, and was employed principally as mere ornament, or as an adjunct to the ornamentation of furniture. This, of course, was far more delicate in its construction than the others. It consisted of minute particles of marble and fictile ware, sometimes not one-twentieth of an inch across, and was more like the modern Roman or Florentine work than the coarser kinds of which we have been speaking. It was of this kind it is supposed that the mosaic was composed which it is reported that C. Julius Cæsar carried about with him on his campaigns. Probably the taste that found vent in this way contributed not a little to his popularity with his contemporaries, and his fame among posterity. Pliny describes with great admiration a mosaic of this character, which represents doves drinking from a vase, which actual work or a copy thereof still exists, and the design must be well known to all who are interested in mosaic work.

The *opus scalpturatum* was somewhat different from the former, inasmuch as in all those cases the various coloured materials were embedded in a layer of plaster or cement, whilst in this the marble itself was made the foundation for a process of inlaying. The marble was hollowed out, the grooves were filled up with grey or black marble, or sometimes with composition. In the Capitol at Rome is preserved a map of the city made in this way. It originally formed the floor of the Temple of Romulus and Remus, and seems to have given the position of every house in Rome. In the cathedral at Sienna a picture is produced by inserting grey marble in a foundation of white, and in the required places deepening the shadows by crossed grooves filled with a black composition. This, of course, is much later work, but probably the Romans carried this decoration to a greater degree of perfection than any remains of their work would lead us to suppose.

There was still another species of mosaic, called *asarotum opus*, which as its name was Greek, was probably introduced from Greece. It would imply an appearance as of an unswept floor, either dotted with crumbs, or having the chips from other workers scattered about it. This probably resembled the Venetian *pisé* floor, or the common Italian *trazzo*. It was rather a trick of an artist than what could fairly be called an artistic work.

The above were the principal styles of mosaic used by the Romans during the time that they remained heathen; the later work though not necessarily connected with Christianity or arising therefrom, is so much influenced by Christian art that we cannot but make a pause between the old and the new. The *vermiculatum*, indeed, did last on into Christian times, of which we have an instance in this country (and it is believed to be the earliest instance) at Horkstow, in Lincolnshire; but in this case pagan deities are mixed up with Christian monogram in a most extraordinary manner, and it almost looks as if the monogram had been introduced by some Christian workman in a surreptitious manner. In the first kind of mosaic which we are about to mention as having arisen after Christianity was somewhat extended—in Italy at least—there was not much more than these monograms to denote the intention of the workers, still it seems to have had its effect upon the work, which henceforth was devoted more especially to churches, and was certainly less used in private dwellings, if not also in public buildings of a secular character. But in the second the religious influence was far more marked. It gave a tone to the whole, and if the mosaics of the fifth, sixth, and following centuries not only surpass all previous work of the same character, but possess a grandeur of their own which we seem quite unable to rival at the present day, it is certainly owing to the deeply-imbued faith and the strength of religious feeling in those early Christians who did not halt between two opinions as to religious art, but strove to teach their people with the teaching of the eye with as much earnestness as they essayed to impress its doctrines by their oral discourses. If, as Mr. Ruskin says, religion has not gained by its alliance with art, it is impossible for any one to look upon the mosaics of San Marco at Venice, or the grand series at Ravenna, in the church of San Apollinare Nuovo, in the Archbishop's private chapel, in the Baptistry of St. John, in the Basilica of San Vitale, the Mausoleum of the Empress Galla Placidia, and, though last not least, the Basilica of San Apollinare in Elasse, outside the town, without feeling that art owes much to the strong religious feeling which prompted the conception and carried through the construction of such heart-stirring and magnificent work.

To return to our description of the various styles of mosaic. The first which came into existence after the spread of Christianity are called the *opus Alexandrinum*, to which we find such constant allusion, and of which so many remains of ancient work is still to be found, especially scattered about through all parts of Italy. This style of work originated in the fact of the Emperor Alexander Severus, who reigned between the years 222 and 235 A.D., having procured a quantity of porphyry and serpentine on his return from Alexandria, and this was inserted in channels chased out in slabs of white marble, in a manner not very unlike the *opus scalpturatum*, which we described before, excepting that this earlier work seems to have consisted principally of white and black and grey, and did not show forth the strong colours of porphyry and serpentine. The production of this work lasted until the beginning of the fourteenth century. The finest specimens, it is said, are to be seen at the Certosa at Pavia; and in this country Westminster Abbey and Canterbury Cathedral furnish examples, both the work of Italian artists.

The next improvement was a return to something like the old *opus vermiculatum*. It consists almost entirely of sacred subjects, in which but slight shadows were used, just as we see in the pictures of the same period, and the whole stands forth from a ground of gold, recalling the sacred pictures in use in the Greek Church. No doubt there was a strong Oriental or Byzantine influence at work upon this art, for the finest specimens are to be found in Venice, the port by which mediæval Europe held its intercourse with the East; in Ravenna, so long the capital of the exarchate dependent upon the Eastern Empire; and in Sicily, which always had an Oriental tinge—

> "Because Greeks are Greeks, and hearts are hearts,
> And poetry is power."

So that we find in this Greek art, flourishing on a soil imbued with much good blood of Greeks, and compelled to teach a religion sprung from Syria but nourished in Greece, much of Oriental repose and grandeur, much of deep and dignified expression, portrayed in fixed and stereotyped forms.

Sir Digby Wyatt gives it as his opinion that the earliest work, such as that at Monreale near Palermo, was produced by first covering the whole ground with gold-surfaced tesseræ strongly bedded in plaster, and that afterwards the patterns to be inserted were picked out and filled up with the various colours required. This, at all events, does not seem to have been the plan on which the mosaicists of Venice and Ravenna worked, for we find their work is gradually fitted round to the outlines of the figures, and by their lines directing the eye to the main purpose of the picture.

There remains but to mention the geometrical glass mosaic, which is usually inserted in grooves of white marble, and made to subserve to the decoration of friezes and columns, and in fine forms of reredos and pulpits. Regular geometrical figures, especially equilateral triangles and hexagons, are the common forms employed, but these are not formed of regular-shaped pieces of glass, but of bits broken off, and in some cases ground down. The pieces from which these fragments were chopped off were originally about six inches square, and half an inch thick. These pieces were fitted to their places, and fastened down with a cement formed of lime and a little powdered

stone. This character of mosaic was common until about the middle of the fifteenth century, when fresco-painting obtained such a mastery over other modes of external and mural decoration that the mosaic, with its Oriental tendency to retain traditional forms, was unable, especially after the taking of Constantinople cut off almost all intercourse with the Eastern Empire, to hold its place in the public estimation. There always has been, however, a certain amount of mosaic made in Rome, in Florence, and in Venice.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIII.—JOHN DALTON, D.C.L.

BY JAMES GRANT.

AMONG those men whose lives form eras in the history of science we may justly number John Dalton, the second Newton of English physics, the author and expounder of the "Atomic Theory," who was born on the 5th of September, 1766, at Eaglesfield, a township in the parish of Brigham, in Cumberland. His father, Joseph Dalton, by the death of an elder brother, became proprietor of a small copyhold estate, which he thriftily farmed with the aid of his sons. He gave his family the best education his slender circumstances would permit, and his second son, John, was educated at a school conducted by a member of the Society of Friends till he attained his twelfth year.

Young Dalton must have made remarkable progress there, and developed early talent, as in his *thirteenth year* he commenced a school in his native village, and continued to teach there until the winter of 1781. All the time he could spare from this vocation was devoted to assisting his father as a farm labourer. At this period he began the study of mathematics, in which he was assisted by a kind and accomplished lady named Robinson. An anecdote is told of the boy teacher which exhibits the early possession of that confidence which formed a leading feature of his future character:—"The correctness of one of his solutions being questioned, he persisted in its accuracy, backing his opinion with a bet, the result of which was a supply of candles through the winter for his little school."

On attaining his fifteenth year he was appointed usher in the school kept by his cousin, George Bewley, at Kendal, where, until 1792, he was entirely employed in acquiring and teaching the physical sciences and mathematics. Prior to this, in 1788, he commenced those meteorological observations which led directly or indirectly to all his great discoveries, and which he continued without intermission until the day before his death. While residing at Kendal he gained the friendship of a blind gentleman, named Gough, who had an excellent library and some chemical apparatus, all of which he placed fully at the disposal of Dalton, who became his assistant and companion, and who in return was never weary of expressing the obligations he owed to him; and to these he referred when, in 1793, he published his first work, entitled, "Meteorological Observations and Essays." His observations on the weight of the atmosphere led him to the discovery of the fact "that the rise and fall of the barometer depend upon the amount of watery vapour floating in the air; every grain of water when dissolved in that medium becoming an elastic vapour capable of sustaining $\frac{1}{24}$th of an inch of mercury. He connected the Aurora Borealis with magnetic phenomena, and explained the cause of the trade winds without being aware of the explanations of others on these points." From 1794 to 1803 he was busy with experiments on such subjects as the force of steam, evaporation and the expansion of gases by heat, the deposition of dew, the fall of rain, the secret origin of springs, the power of fluids to conduct heat, the constitution of mixed gases, all the while conducting his meteorological observations with singular regularity and minuteness. For more than fifty years of his life he was in the habit of making a dozen of those observations daily; and it would indeed have been remarkable if from such a mass of notes such a man as Dalton did not deduce much that was new to science, and theoretically important.

Some time prior to the publication of his "Observations" he had thought of qualifying as a lawyer or physician; but changed these views on obtaining the more congenial employment of Professor of Mathematics and Natural Philosophy in the New College, Mosley Street, Manchester, to which city he removed, and there spent the remainder of his days. He became a leading member of the Manchester Literary and Philosophical Society, to the Transactions of which he contributed a series of papers containing the results of original researches of the greatest value to science.

In 1803 he published an essay "On the Tendency of Elastic Fluids to Diffusion through each other;" and a second "On the Absorption of Gases by Water and other Liquids;" the latter containing the first announcement of his discovery of the laws for combining proportion, and the germ of his celebrated hypothesis, *the atomic constitution of matter*. In this he employed his usual mode of illustration, representing the particles of the liquids by one kind of dot, and the particles of the gases by another kind, showing how fully a belief in the atomic theory of formation had taken hold of his mind. He took a mechanical view of the absorption of the gases by liquids; but it was asked, "If this mingling were a mechanical matter, and not chemical action, how does it happen that water dissolves its own bulk of one gas, carbonic acid, and only three per cent. of its own volume of another, such as oxygen?"

Dalton saw this difficulty, and replied, "Why does water not admit its bulk of every gas alike? This question I have duly considered, and though I am not yet able to satisfy myself completely, I am nearly persuaded that the circumstance depends upon the weight and number of the ultimate particles of the several gases, those whose particles are lightest and single being least observable, and the others more, according as they increase in weight and complexity." To this he added a table of the relative weights of the ultimate particles of gaseous and other bodies, and this was the first attempt at a table of *atomic weights*.

The atomical philosophy has been alleged to be atheistical, or allied to atheism; but the learned Dr. Cudworth says it existed before and without atheism, and that Democritus and Leucippus are to be regarded as the first inventors of atomical philosophy. Of the theory in *chemistry*, though first noticed by Higgins, of Dublin, in 1789, and by Richter, of Berlin, four years later, the doctrine was neither fully expounded nor completed till Dalton published his "New System of Chemical Philosophy" in 1808.

Five years before this he had lectured on the subject in Manchester and at the Royal Institution of London. In 1804 he fully explained it to Dr. Thomson, of Glasgow, who spent a few days with him in Manchester, and in 1807 he lectured publicly on the subject in Edinburgh and Glasgow. From thence till 1810 he was chiefly occupied in the prosecution of analyses to verify his theory, and in teaching mathematics, though he was not a fluent speaker, and did not possess much talent for teaching. He succeeded, however, in proving his theory, in direct opposition to Berthollet, who maintained with great ability the doctrine of indefinite affinity, or the opinion that substances disposed to combine united in every possible proportion; that the several compounds formed by varying proportions of the same ingredients are all multiples of the first.

Dalton had ever round him in Manchester a circle of appreciating friends, who more than once offered to provide him with a competence to the end that he might give his undivided attention to the pursuit of scientific investigations; but these offers he declined. In 1814 his portrait was painted by Allen, and engraved for distribution. In 1822 he visited Paris, and was introduced to La Place and all the more distinguished of the French philosophers. He was invited to attend the meetings of the Institute, and was everywhere treated with such distinction that, though naturally retiring and modest, he said on his return home: "If any Englishman has reason to be proud of France, I am that one."

In 1826 the Royal Society of London accorded to him the royal gold medal, of fifty guineas value, placed at their disposal by George IV. He attended the earliest meeting of the British Association for the Advancement of Science, held at York in 1831. Its next assembly was at Oxford, in 1832, when the degree of D.C.L. was conferred upon him by the University. When the Association met at Cambridge in 1833, its president, Professor Sedgewick, closed a speech full of compliment to Dalton by announcing that "His Majesty William IV., wishing to manifest his attachment to science, and his regard for a character like that of Dr. Dalton, had graciously conferred on him, out of the funds of the Civil List, a substantial mark of his royal favour." This "mark" was raised to £300 per annum in 1836. For his marble statue at Manchester, by Chantrey, £2,000 was subscribed;

and, when in London, he was presented to William IV. by Lord Brougham, then Chancellor. In 1834 he was in Edinburgh, where fresh honours awaited him. The University conferred upon him the degree of LL.D.; the Town Council gave him publicly the freedom of the city, and he was elected a Fellow of the Royal Society of Scotland.

In the seventieth year of his laborious and useful life he had a paralytic stroke, which left his right arm powerless, and also deprived him of speech. Prior to this very year he had always enjoyed robust health, and was fond of outdoor exercise. He had made a yearly pilgrimage to his native mountains of Cumberland and Westmoreland, and never failed to climb, with all a borderer's delight, Skiddaw and Helvellyn. Every Thursday morning he was wont to devote to the old English game of bowls. He was methodically regular in attending twice on Sunday the meetings of the Society of Friends; and on the same day for more than forty years he dined at the house of a friend. Dalton was "a simple, frugal, strictly honest, and truthful man. For the independence, gravity, and reserve of his character, he was doubtless much indebted to his birth as a Cumberland yeoman, and his long connection with the Society of Friends."

A second and third paralytic stroke greatly increased his infirmity, yet, singular to say, he was able to be present at a meeting of the Council of the Manchester Literary and Philosophical Society in May, 1844, when he was presented with an engrossed vellum copy of a resolution of that body, passed at their annual meeting. It recorded "their admiration of the zeal and perseverance with which he has deduced the mean pressure and temperature of the atmosphere; the quantity of rain for each month and for the whole year; with the prevailing duration and force of the wind at different seasons in this neighbourhood, from a series of *more than two hundred thousand observations*, from the end of the year 1793 to 1844, being the period of half a century."

Dalton received the resolution sitting in a chair, and was unable to articulate a reply, though his face expressed the deepest emotion. This was on the 19th of May, and eight days after, he expired. His remains were interred in the cemetery at Ardwick Green. By his will he had left £2,000 to endow a Dalton Chair of Chemistry in the University of Oxford; but before his death he revoked the bequest by a codicil, for the purpose of bestowing the money on certain persons who had befriended him in his earlier and more dependent years.

THE LATHE.—VI.

By Henry Northcott.

SLIDE-RESTS: THEIR USES AND ADVANTAGES (*continued*).

There is yet another form of slide-rest described in the old book I have mentioned, devised especially for the production of spheres, and this rest is worked out into a very neat instrument. To produce a spherical curve is, of course, no more difficult than to produce a straight line; indeed the former is the easier, but the requirements of the spherical slide-rest do not appear to have been so easily understood. In the spherical slide-rests, illustrated by Figs. 19, 20, and 21, there are two slides—a slide for producing a circular movement, or movement around a centre, and a slide for obtaining a right-line movement, or movement from the centre. The whole of this rest is of metal, as the former ones are, and the lower part or baseplate A is made to fasten down upon the lathe-bed, the projecting piece B going down between the two cheeks of the bed to act as a guide in keeping the position of the slide, and it is held in place by a capstan-headed bolt C, with a cross-piece or bridge spanning the lathe-bearers below. All this is much the same as in the previous examples of ordinary rests.

The top part of A is trued up and rendered very smooth, and also perfectly parallel to the lathe-bed surface when the rest is in place. Accuracy of workmanship, it may be remarked, is absolutely essential to ensure the satisfactory action of all kinds of slide-rests. The baseplate A is rectangular, but its upper part D is formed circular by merely turning off the corners, and this leaves a circular plate with a true flat surface. Upon this circular table is placed a circular plate of brass, F, of the same size, and this brass plate is fitted nicely down upon the other surface: and by means of a conical pin going through the brass plate and screwing into the plate below, the two surfaces are kept in close contact. The conical pin also acts as an axis or centre around which the circular disc may rotate. The extreme edge of the disc should be graduated or divided into 360 for convenience of adjustment, by reading off the extent of movement of the disc, as compared with the stationary plate below, which carries a zero mark or line to enable the movement to be easily compared. The broad edge of the disc is furnished with fine teeth, so as to convert it into a worm-wheel, and an endless screw or worm, with corresponding thread, is carried in brackets attached to the stationary part A, and is arranged to gear with the teeth on the edge of the disc F. This arrangement of worm-wheel and worm, or tangent-screw, is best shown in Fig. 21, which is a plan of the entire rest. From this view it will be seen also that the axle of the tangent-screw is continued outwards towards the operator, and is furnished with a small winch-handle, by means of which the screw is caused to rotate. The top surface of the worm-wheel is also rendered true or accurately flat, and two side pieces or cheeks, H, H, Fig. 19, are fastened down upon it, forming a female

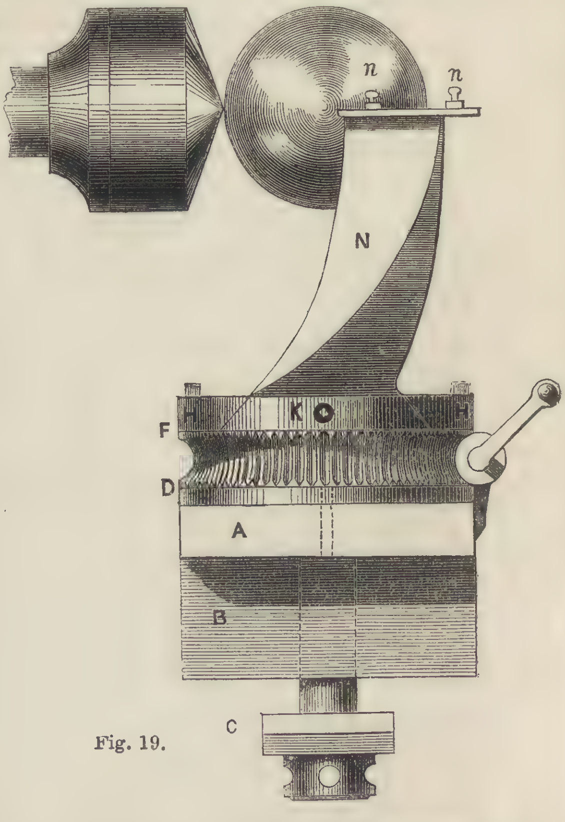


Fig. 19.

slide for the part K. The shape of these cheeks, and the manner in which they are placed upon F, are plainly shown in Fig. 21, where are seen the heads of the four screws which are used to fasten the cheeks down in their places. K is a male slide, and it is continued upwards in a spiral form, so as to terminate in a narrow edge suitable for carrying a cutting tool. This form of support gives great solidity and is rather ingenious, but it is somewhat cumbersome, and is now discarded. The slide part of K is rather different from the slides previously illustrated, inasmuch as the male and female slides are now reversed, but the arrangement is clearly shown in the figures. The traverse of the slide is brought about by means of a screw, and the top slide carries a small pointer *a*, Fig. 21, which slightly projects out over the slide cheek, the edge of which is graduated. These graduations are for the purpose of adjusting the radius of the curves to be produced. The tool-holder portion of this slide-rest is of a very simple construction. The tool is placed upon a narrow edge, being the extremity of the part K, and is held down by means of two clamps and screws, *n*, *n*.

The action of this kind of slide-rest is obvious from the several figures, which not only illustrate the construction of the rest, but its position relative to the work it is designed to execute. It will be seen that the centre of the slide-rest, or the centre of the axis around which the tangent-wheel F rotates, is placed immediately underneath the centre of the required sphere or curve; that is to say, a plumb-line passing down through the centre of the sphere would also pass through the axis of the slide-rest. The tool being in its place, the depth of cut and the size of the sphere would be determined by the movement of the slide K, which has the effect of regulating the distance of the tool's point from the same plumb-line, or rather from the centre of the sphere. The traverse of the tool's point, or its movement along the surface of the work in the required curve, is obtained by moving round the tangent-wheel F, carrying the other slide by means of the endless screw at the side.

No kind of spherical slide-rest will produce a sphere from the solid at one operation, as a small part must be left as a support. In the example before us in Figs. 19, 20, and 21, the sphere is shown very nearly but not quite complete. The whole of the outside of the curve is described and easily formed on the material, but a small neck is shown by which the ball is connected to the main portion of the material from which it has been cut. In practice no inconvenience results from the necessity of leaving a connection, as the part finally left is extremely small. It is usual to leave rather a large neck, so long as any heavy cuts remain to be taken away from the ball or any great strain put upon it; but when the heavy work is done and the finishing cut has to be taken, the neck may be reduced in size, and after the ball is otherwise completely turned, the neck may be still further reduced in size. By using a sharp-cutting hand-tool and running the lathe fast, the ball may even be completely severed from the stock and the sphere detached in a perfect form.

I have been at the pains to describe these old forms of slide-rest with some particularity, as it does not appear to be understood that the slide-rest is so old an invention. Most writers attribute the invention to Maudslay, the celebrated English mechanical engineer, but this is evidently incorrect.

Having the slide-rest, which to a great extent superseded the workman's hand in the execution of the work, but still required to be actuated by him, the next improvement was to render it unnecessary for the workman even to turn the winch-handle, and to make the motion of the tool automatic by connecting the traverse screw in some way with the lathe-spindle or some part of the lathe mechanism. This is effected in various ways, and one of the earliest schemes is shown at Fig. 22. The motion in this case is derived from the foot by the means already mentioned, and this motion is first given to an overhead shaft, which in turn drives the lathe-spindle through a crossed gut or cord and a pair of stepped V-pulleys. The overhead shaft carries another stepped V-pulley, for driving a pulley which is placed upon the end of the traverse screw of the slide-rest instead of the usual winch-handle. The relative speed of the lathe-spindle, the overhead shaft, and the slide-rest screw, can be adjusted by placing the guts upon the various grooves of the pulleys, so that the fineness of the cut may be regulated to the work in hand.

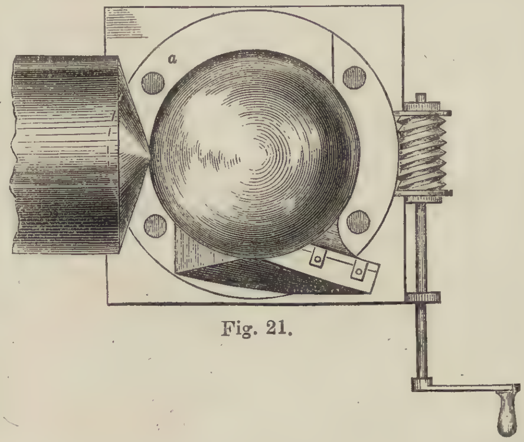


Fig. 21.

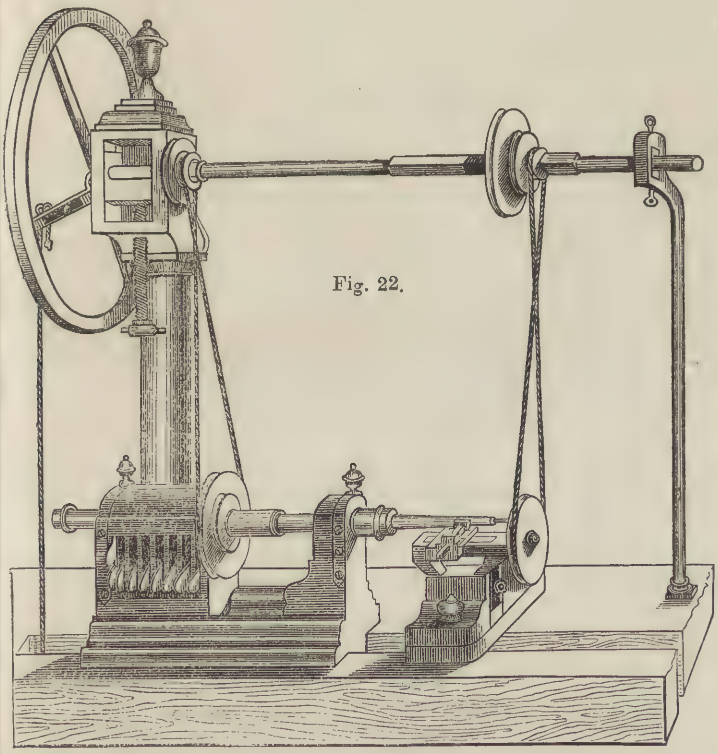


Fig. 22.

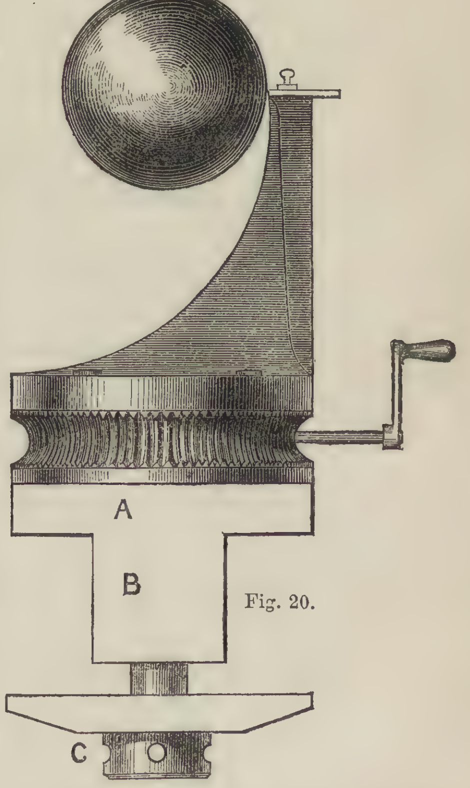


Fig. 20.

FISH CULTURE.—VI.

By Greville Fennell.

DETRIMENTS TO FISH CULTURE—BREEDING PONDS AT STORMONTFIELD.

Mr. Wilhelm Hartman has contributed much valuable information to the *Transactions of the German Fishery Society*, and as his language is simple and his conclusions coincide for the most part with our own, while they give us the last information upon a subject now of great European interest, we give an abstract from his paper, making those comments we deem requisite.

Whenever the question of fish culture concerns attempts at propagation which may be useful for our domestic economy, we always do best when we closely adhere to natural history, and especially to the history of the development of the object to be treated. More than anywhere is this course to be observed in fish rearing; and we do not scruple to assert that the various incorrect views on this branch of animal culture, the over and under estimation of the importance which was attributed to it in respect to natural economy, and, finally, the comparatively not very brilliant results which have been hitherto attained, have mainly their grounds in the fact that trouble was not taken to study the nature, the development, and mode of life of the fish by personal observation and practice, nor even to obtain information from those who were acquainted with them.

If we observe the propagation of salmon in natural freedom, as did Gehin and Remy that of trout, we see, in the spawning time the female ascends the river followed by several males. At a suitable place she stops, hollows out a shallow, deepening in the sand or gravel by movements of the tail, lays a heap of eggs in it, and swims further upwards. One of the males, usually the strongest, swims quickly there, and sprinkles his milt over the eggs. The impregnation of the eggs, then, occurs, not as with mammalia and birds, through the act of copulation, but only after they have been laid. Here the first loss immediately follows, as about 30 per cent. of the eggs laid are not touched by the fertilising milt, and therefore cannot come to a development. A second loss occurs almost at the same time; as those males which cannot attain to the fructification of the eggs fall upon them ravenously and devour a part of them; this may be reckoned at 10 per cent. The remaining 60 per cent. are exposed to the attacks of innumerable enemies to which they fall a prey—fish, crawfish, water-mice, aquatic birds, etc., and lastly to be frozen, such, of course, being only the eggs of winter fish, to which, however, the most precious sort belong. Thus there are about 30 per cent. hatched out of the eggs laid, but now the destruction goes on seriously. The eggs were at least somewhat protected by a tolerably tough elastic cover, and the sand partly covering them; the helpless young, on the contrary, lie three to six weeks with the most easily-injured navel-bag without protection, exposed to their weakest enemies—small larvæ, insects, water-beetles—open on the gravel of the bottom; and it will be well if, at the time when the little fish, on the absorption of the navel bag, begin to swim about, to feed, and become self-providing, there remain half a dozen of those hatched out. In consideration of such enormous losses, the task of fish culture, to which the somewhat inapplicable name of artificial is given, becomes sufficiently evident. It consists in protecting the material capable of development which Nature produces in a colossal quantity (a salmon, *e.g.*, lays annually 25,000 eggs) against the losses to which it is exposed in open waters. Of special importance is this for salmon and trout, because with them the most dangerous period—that of the navel-bag—lasts the longest, and also because these fish have a higher value than the others. It is therefore natural that more trouble and a greater outlay of capital should be applied to their increase. To those who take an interest in the various details, we* recommend a journey to Freiburgh during the winter months to inspect the fish culture of the Burgomaster Schiester.†

Visitors to Sunbury should inspect the nursery near the lock, in which Messrs. Buckland and Ponder rear their fish after hatching out for the stocking of the Thames. Nurseries should be carefully watched, and this one, although of great extent, is covered with wire netting to prevent the kingfishers—who invariably find out where the young of trout are—from picking them up. The youthful jack is likewise an insidious enemy, and will introduce himself amongst the young through any aperture which will admit an eel. Eels are enemies of all fry of fish. The carnivorous beetle should be searched for with a small mesh-net amongst weeds. The larvæ of the dragon-fly are also very destructive.

The Museum of Economic Fish Culture being an educational establishment, yet wholly supported by private enterprise and private funds, and without any apparent hope of Government aid, is the most accessible place to obtain every information upon fish culture. There is always some one in attendance who is skilled in the process; and Mr. Frank Buckland is ever ready, either personally or through his secretary, to reply to any queries directed to him relating to this interesting subject. The museum is, however, the place for fish-hatchers to compare, note, and deduce useful facts.

This is our conclusion with regard to many establishments, and that at Stormontfield especially, that we are breeding small fish for the big ones to eat. We fully agree with Mr. John Richardson that the kelts eat the parrs, but here we have no remedy, and Nature must take her course.

Mr. Thomas Ashworth was one of the most distinguished of our pioneers of salmon culture in all its aspects, and Galway the best managed and perhaps the most productive fishery in the kingdom.

Mr. Russel truthfully observes that whatever doubts may rise as to the good of introducing certain fish into rivers to which they have heretofore been alien, and thus give the vested inhabitants of those rivers other competitors for their food, there can exist none in regard to the salmon, as he is not a formidable competitor with any other species as to food, and moreover is the most valuable and desirable of all fish. Of course there is, in the case of the salmon, the heavy drawback arising from its being migratory and vagabond in its instincts and habits; but still much can be done, and not a little has been done, to increase the stock of salmon by semi-artificial propagation, and semi-domestic rearing. It is obvious that salmon *ab ovo*, and before that, up to the age of puberty, are, in their natural abodes, exposed to very great perils; thus, besides those enumerated elsewhere, there is the loss by spawn being deposited during floods, when the rivers are high, in positions where, when the waters fall, it is destroyed by frosts and drought, or trampled under foot of man or beast—an evil of late very greatly increased by the extension of land drainage, especially the hill or open drainage, which causes the rivers both to rise higher and to sink lower and more rapidly.

What breeding-ponds have already done and have shown *can* be done, in applying a remedy at this point is striking. Mr. Francis Francis gives us the early history of the operations in the breeding of young salmon at Stormontfield. A gentle slope from a mill-lade, running parallel with and sixteen feet above the Tay, was chosen, whence a sufficient supply of water could be obtained. Three hundred boxes were laid down in twenty-five parallel rows, each box being partly filled with clean gravel and pebbles, and protected at each end by perforated zinc. Filtering beds were formed at the head and foot of the rows, and the boxes were charged with 300,000 ova by the 23rd of December. On the 31st of March the first ova were hatched. A pond had been provided for the fry; this pond was 223 feet long by 112 feet in the broadest part. It was subsequently found to be far too small. By June the greater part of the fry were admitted into the pond, being then about an inch and a half long. There they were fed with boiled liver daily, and, on the 24th of May, or nearly twelve months after their being hatched, a large portion of them having assumed the smolt scale, left the pond, and commenced their descent to the sea, an equally large number remaining behind, and showing no disposition to assume the migratory dress of the smolt. Many of the smolts which then migrated were marked by the cutting off of the adipose fin, and a large number of them were re-taken ascending the river again, at various periods up to August, in the form of grilse, and varying in weight from 6 lb. to 9 lb., according to the time they had remained in the salt water—thus proving the disputed

* Wilhelm Hartman in the *Transactions of the German Fishery Society*, 1871.

† The eggs of fish were distributed from Huninguen with various results. The most successful place was Wolfesbrunnen near Heidelberg. There are many localities in England where the same thing might be done if fish culture were carried out on a scale in comparison with its requirements.

question as to the rate of growth of the salmon. From 1853 to 1862 the boxes were stocked five several times. One of these years (1854) proved a failure. It was found impossible to stock the boxes oftener than every other year, owing to the limited accommodation for the fry. Great benefits must have accrued to the Tay from these operations, but it was rendered impossible to estimate them, by reason of the prejudice and ignorance of the fishermen, who failed to send notice to Mr. Buist of the marked fish re-captured, so that the proportion of fry that returned to the river as grilse and salmon could not be computed.

PHOTOGRAPHY.—VI.

By J. C. Leake.

POSITIVE PRINTING.

The production of positive proofs upon paper—that is to say, of pictures which have their light and shade in their proper and natural order instead of being reversed (as is the case in negative pictures, such as we have before described), is of course a matter of much importance; as these being the final result of the photographer's operations will afford the opportunity of judging of the success or non-success of his work. There often prevails among even professional photographers an idea that printing a photograph is a very simple and easy matter, and frequently so little care and skill are expended in this portion of the work, that that which has been given to the production of the negative is completely wasted. It is perfectly true that a good print may be obtained by a person who is unskilled in making a negative, but it must be remembered that the chemical processes involved are as delicate and subtle as those employed in the first-named process; and, if pure, bright, and brilliant prints are desired as well as permanent results, the same care must be given to one as to the other. As is the case with respect to the production of negatives, there are many methods employed in making positive prints; but, for the sake of simplicity and clearness of description, we shall here confine our instructions to those employed in what may be termed the standard process—namely, that by which the proofs are obtained upon albumenised paper. In outline this process is as follows. A sheet of paper of suitable quality is selected, and coated with albumen or white of egg, to which is added a suitable chloride, such as that of sodium or ammonium. After a few minutes the sheet is removed from this bath and dried. In this state it is totally insensitive to light; but upon its being floated upon a solution of nitrate of silver, the chloride retained upon the surface by the albumen combines with the silver in the bath, forming a chloride of silver, which rapidly blackens under the sun's rays. A sheet of this paper is placed under the negative in a suitable frame, and exposed to the action of light, when of course those parts of the negative which are the least dense allow the rays to reach the sensitive paper which they darken; while those which are protected by the opaque portions retain their original whiteness. This change is effected in exact proportion to the varying shades in the negative; and the result is a picture true to the light and shade of nature, and of the most exquisite fineness and delicacy, both of outline and gradation.

In this state, however, the picture is not only liable to fade from the darkening of the whole surface, but it is of an unpleasant colour; the alteration of which necessitates what is termed the toning process. The print is well washed in order to remove any unreduced nitrate of silver which may remain upon its surface, and is afterwards immersed in a solution containing chloride of gold. In this it rapidly assumes a pleasing colour, which varies according to the time during which the action is continued. All that now remains is to fix the picture by removing the unaltered chloride of silver, which is effected by placing the proof in a solution of hyposulphite of soda. The proof must now be thoroughly washed to remove the fixing salt, when it will be ready for mounting. From these remarks it will be seen that although the process of printing is simple, some care and skill are required in the various manipulatory details, and these we shall now proceed to describe.

Although it is scarcely to be expected that the amateur will prepare the albumen-coated paper for his own use, seeing that it may now be readily procured at a less cost than he could make it for himself, we here give the requisite formula, in case he should elect to do so, merely suggesting that without a proper room heated to a high temperature, he will find it a tedious and difficult process. With respect to the paper employed, it should be of fine quality, smooth surface, and of moderate thickness. Papers of foreign manufacture are mostly used for photographic purposes, and the two varieties known as "Rive" and "Saxe," are considered the best and most suitable. Of these the Rive is best for portrait work, while for landscapes or pictures of large dimensions Saxe is preferable, on account of its clearness and freedom from spots and other defects. The method of preparing the albumen is as follows:—Take of pure albumen obtained from fresh eggs, and free from yolk, fifteen ounces, which place in a wide-mouthed bottle capable of holding at least thirty fluid ounces. Dissolve in two or three ounces of distilled water one hundred grains of chloride of ammonium, and mix it with the albumen. Now carefully select and wash about half a teacupful of small smooth stones, about the size of peas, and place them in the solution. The bottle should now be carefully corked, and the whole agitated until it is entirely converted into froth.

Upon the perfect beating of the albumen the success of the operation mainly depends, as, if this be not thoroughly effected, small shreds of membrane remain upon the surface of the paper and cause streaks and stains. When thoroughly beaten the albumen should be poured off into a tall vessel, and allowed to settle for several hours before use. The stones left at the bottom of the bottle may be washed and kept for future use, as by cutting through the liquid they materially assist the perfect mixing of the albumen and the water and salt. When thoroughly settled the solution should be poured into a flat dish of the required size, to the depth of about half an inch, and carefully skimmed by means of a slip of paper. A selected sheet of paper should then be taken by two of the corners, and being bent into a sharp curve, the centre part should be laid upon the solution, the corners being allowed to follow gently down, taking the utmost care to avoid air-bubbles. Of course, one side only is coated in this way, and care must be exercised in keeping the albumen from flowing over the edges and on to the back of the paper. After having remained upon the solution about one minute the sheet should be removed, and suspended by two corners until dry. As we have before remarked, the albumenising of paper is a difficult operation, and we should advise the operator to procure that which is ready prepared, wherever possible, rather than undertake to perform it for himself.

The next operation will be that of sensitising the albumenised surface, and preparing it for the action of light. We may here observe that although the paper will rapidly darken under the action of light after sensitising, yet it is not nearly so delicately sensitive as the collodion film before described; and consequently much more light may be admitted to the room in the former than in the latter case. The albumenised paper may be rendered sensitive by floating it for three minutes upon a solution prepared as follows:—Take of nitrate of silver five hundred grains, to which add ten ounces of distilled water, and dissolve. Filter and pour it into a flat dish to the depth of half an inch, and remove any scum or dust with a slip of paper as before described. The paper having been cut to the required dimensions, should now be laid face downwards—that is to say, with its albumenised side—upon the solution, precisely as directed for albumenising, and with the same precautions as to the avoidance of air-bubbles. Having remained upon this solution for the space of about three minutes, it should be raised at one corner by means of a pair of bone forceps, and gradually lifted completely off the solution. It should then be well drained into the dish, and finally suspended by one corner to dry, removing the last drops of solution by means of floating paper applied to the lower corner. When dry the paper will be sensitive to light and ready for exposure in the printing frame.

The printing or pressure frame generally in use is a very simple and inexpensive piece of apparatus, consisting of a frame of wood, into which is fitted a square of thick plate glass. Upon the edges of this enclosing frame are hinged two or more arms of wood, into which screws are placed in order to ensure perfect contact between the sensitive paper and the negative. A backboard of wood, hinged together in one or more places, is made to fit into the frame upon the plate of glass, and the screws are then adjusted so as to secure the whole in absolute

contact. In order to print a picture, the negative (having been first cleaned at the back) is laid upon the plate glass face upwards, in such a position as to allow of the inspection of one part of the picture while printing, without the disturbance of the other. A piece of sensitive paper rather larger than the negative is then laid sensitive side downwards upon the negative plate. A piece of felt (felt carpeting will answer) or a few folds of cloth or blotting-paper are then placed over the paper in order to equalise the pressure, and ensure absolute contact. The backboard is then placed in position, and the arms having been secured, the screws are adjusted, and the whole tightly compressed. The amount of pressure required is not considerable, but perfect contact between the paper and the negative must be secured. The whole must then be exposed to the action of light, either in the sun or in open daylight. If the light be good a very few minutes' exposure will produce a marked difference in the appearance of the paper, the unprotected portion becoming rapidly darkened. If the negative be of good quality and of average density, as soon as the edges of the paper show signs of bronzing, the pressure frame should be removed to a room in which the light is only moderately brilliant, and one half of the back unscrewed. The backboard and felt as well as the paper may now be turned back, and the progress of the printing may be inspected. When the impression is slightly darker than is required in the finished picture, the paper may be removed from the printing frame and placed in a portfolio for further treatment.

The requisite number of prints having been thus printed, the edges should be roughly trimmed up to the size of the negative, when they will be ready for the further operations of toning and fixing. In trimming the proofs care should be taken to preserve every fragment of sensitised paper, as the whole of the nitrate of silver with which it is impregnated is easily recovered, and of course valuable. A large dish should be provided, as well as a good supply of clean water, and if possible a large pan or tub into which the washings (which will contain a good quantity of nitrate of silver) may be poured and preserved. The dish should be about two-thirds filled with clean water, and the prints immersed one at a time and well rinsed, of course taking care not to tear or injure them. When all have been thus treated, the first washing should be poured off into the waste tub and the dish again filled, continuing the rinsing with the same precaution as before. The second washing having been effected, and the water having been preserved as before, a third quantity should be placed in the dish and a small quantity of common table salt added, which will convert any remaining nitrate of silver into chloride, an important point when permanency is desired in the finished print. If this third washing solution be poured into the waste tub, it will assist in precipitating the nitrate of silver; a matter of which we shall treat further on.

It will be observed that the proofs will have assumed a very unpleasant colour under this treatment, most likely a brick red, and in order to remove this, they must be submitted to the action of the toning bath, in which they may be brought to almost any shade which may be thought desirable. The toning bath is prepared as follows:—Take of acetate of soda fifty grains, which dissolve in sixteen ounces of distilled water. Dissolve three grains of chloride of gold in two ounces of distilled water, and pour the latter into the former solution, stirring with a glass rod. This solution should be prepared at least twelve hours before use, and it may be used over and over again, merely adding small portions of the last-mentioned gold solution as it begins to work too slowly. It is, however, better to allow at least the time we have mentioned to elapse after the addition of the gold before attempting to work with it. If this precaution be neglected it is very apt to work irregularly, especially if the quality of the paper employed be not of the best.

Having poured into a deep dish enough of this toning solution to float the pictures freely without touching each other (say about two inches), proceed to remove them one at a time from the water into the solution, thoroughly soaking each one before the next is introduced. Not more than five or six should be toned at once until the operator has acquired some experience at this kind of work, or some will inevitably be spoiled by over or unequal action. The proofs must be kept constantly moving, and be continually turned over and separated, for wherever they adhere the toning action will stop, and ugly red patches will result. In a few minutes the toning process will be observed to have commenced, the proofs gradually passing from a red to a brown tone, then from brown to purple, and finally to black and grey. The coloration of the proofs should be allowed to continue until rather more advanced than is required in the finished print; as the fixing process will restore a little of the original redness. When the toning is judged to have proceeded to the required extent, the proofs should be removed to a dish or pan containing clean water, and thoroughly washed, in order to remove the gold solution and stop its further action. If the whole batch of prints have not been toned at once, the remainder may now be operated upon as before described; leaving the first batch to await the fixing process until such time as the whole are ready. The great evils which the operator has to guard against in this process are unequal and over-rapid toning, neither of which he is likely to encounter if the directions given above are strictly carried out. In very hot weather the bath frequently works very quickly, and when this is found to be the case it may be freely diluted with distilled water until it becomes easily manageable. If, on the other hand, it works too slowly, it may be warmed to sixty or seventy degrees, and in very cold weather it must be kept fully supplied with gold, when quick working and brilliant tones are desired.

The proofs will now be ready for the fixing process, which is one of the utmost importance; as the permanency of the work depends very much upon its proper performance. The solution used for this purpose is one of hyposulphite of soda, which is made in the following proportions:—Hyposulphite of soda six ounces, common water one pint. For use pour into a dish enough to freely float the prints, and keep them moving therein at least fifteen minutes.

The great point to be attained in this process is to subject all parts of each proof to the action of the hyposulphite solution in order to remove the whole of the sensitive silver salts, consequently the prints must be kept constantly in motion, the manipulation being precisely similar to that above described as required for the toning process. As soon as the fixation is completed, the prints must be thoroughly washed in as many waters as may be convenient, in order to remove the whole of the hyposulphite. As may be imagined, this is a difficult matter; but it is one upon which the success of the whole depends. The smallest trace of this salt will, if left in the print, inevitably destroy it sooner or later, and consequently its removal as completely as possible is absolutely essential. Many mechanical contrivances have been introduced from time to time to effect this, but practical experience has proved that nothing is so well adapted to the work or so really effectual as proper washing by hand. After as many as ten washings have been given, directly after the prints have been taken out of the bath the whole batch should be placed in a large pan to soak for some three or four hours. They should then be thoroughly washed and drained for some minutes, and again immersed in clean water for a like time. After this treatment has been repeated several times a final rinse should be given in water heated to about one hundred degrees; when they may be blotted off and dried for mounting.

The operation of printing may now be considered as completed, and the proofs may be mounted as the taste of the operator may suggest. In concluding this section of our subject we may offer some suggestions upon one or two points connected with the printing process. In the first place, where really first-rate work is required, the sensitising, exposure, toning and fixing processes should all be performed upon the same day; especially during the hot months of summer. Secondly, the strength of the nitrate-of-silver bath is a matter of vital importance, and as it is rapidly reduced when in use, it must be constantly replenished with fresh crystals. The discoloration which will occur after floating the paper may be removed by agitating after the addition of a little kaolin or China clay. The utmost care must be exercised in order to prevent any contamination of the paper, prints, or chemicals with the hyposulphite of soda; and more particularly is this caution necessary with respect to the toning bath.

As in the case of the collodion process, we have here omitted all reference to failures, leaving these and their remedies for consideration in our next article, as well as some modifications of the printing processes which are sometimes required.

MINING AND QUARRYING.—XIX.

BY GEORGE GLADSTONE, F.C.S.

COPPER.

ABUNDANCE AND DISTRIBUTION OF ORES—HOW MINED—CHEMICAL COMPOSITION OF PRINCIPAL ORES—DRESSING—ASSAYING.

Unlike tin, with which metal it is so much associated in Devonshire and Cornwall, copper is very widely distributed in Nature. In the British Isles the principal localities where it occurs, besides those already named, are North Wales and Ireland; but the ore has at times been worked to a considerable extent in Staffordshire and Shropshire also. Many of the richest home mines have been worked out; and it is beyond a doubt that were it not for the large foreign supplies, the price of pure copper would have risen considerably during late years, instead of having declined, as has been the case.

Very rich deposits have been discovered from time to time in various parts of the world; and as the facilities increase for conveying the ores to the places of shipment, these foreign supplies enter into competition with those of the British mines. Cuba, Spain, Italy, Australia, Chili, the Cape of Good Hope, and other countries which have the advantage of being in easy communication with England by sea, all supply ores in large quantities; and several others would also enter into the competition, were it not for their less favourable situation. Siberia, for instance, possesses very extensive deposits, and so does the interior of Canada, where indeed there are some of the most remarkable known.

The ore generally occurs in lodes or veins in the palæozoic and metamorphic rocks; and so far as English mining is concerned, the most typical examples of mining for copper are to be found in Devonshire and the adjoining county. The Devon Great Consols mine has been in late years the most successful of all the copper mines in that district; but there are several others which are conducted on a very large scale, and which have yielded immense returns of ore.

Fig. 13.—WORKINGS IN FOWEY CONSOLS MINE.

The plan upon which copper mines are managed underground is so similar to that already described under the head of "Tin," in Article XV., that little need be added; one or two additional particulars may, however, serve to give an idea of the magnitude of some of these works, and a more intelligible one of how they are carried out. The adit level, and the purpose for which it is made, have been described. A general system of drainage, common to the whole of the district, is sometimes adopted by miners; and such adits as these are grand specimens both of human industry and engineering skill. Thus, the Great Adit, as it is called, which carries off all the superfluous waters from the mines of Redruth and Gwennap, is (including its branches) about thirty miles in length. It may readily be imagined, too, that the most powerful machinery must be required to pump up the water to the adit, from the bottom of the deep mines, such as the Tresavea, the workings in which have already been carried to a depth of more than 350 fathoms. Indeed, ever since the application by Watt of steam to pumping machinery, the Cornish engines have been celebrated for the amount of work they perform in proportion to the consumption of fuel; and a healthy rivalry in this particular is maintained by registering the duty of the several engines, and publishing the results periodically.

The quantity of timber employed underground is prodigious. Sometimes baulks of timber are fixed crosswise between the walls of the lode, to prevent them from collapsing, as in Fig. 13; but if the rock is tender, the galleries are timbered in a more methodical manner, as shown in Fig. 14. The shafts are frequently divided into segments, and lined, and the boxes for raising the ore made to run in grooves, as is commonly the case in deep coal mines, but the old-fashioned kibble or bucket is still in use. Fig. 13, already referred to, illustrates a part of the workings in the Fowey Consols Mine: the wide space has been worked out, because there the lode indicated sufficient promise of ore; but the next portion, being less encouraging, has been left, and a gallery no larger than is necessary for the purpose of exploration has been driven through it.

Copper occurs in Nature in several combinations; but the ores of commercial value may be reduced to three classes—the sulphides, the oxides, and the carbonates. The former includes the grey and yellow ores, the grey being comparatively rare, while the yellow is the most prevalent of all, being familiarly known as copper pyrites. Though containing usually but a small percentage of metal, it is the ore upon which our miners principally rely. The carbonates may also be distinguished by their colours; the blue is termed azurite, and the green malachite, by mineralogists. The green variety is the best known, on account of its capacity of being cut and polished, when it furnishes a highly ornamental stone, the varieties of tint and the concretionary forms displayed being very beautiful.

The grey cuprous sulphide (Cu_2S) should contain theoretically 79·8 per cent. of copper, but it is rarely altogether free from other minerals. It not unfrequently includes a considerable proportion of arsenic, iron, and silicon. The yellow sulphide, commonly called pyrites, is a compound of the former with the ferric sulphide (Fe_2S_3), so that it rarely contains more than about 10 per cent. of metallic copper; but it frequently occurs in such large masses as to make up by quantity for the comparative lowness of its produce. The Parys Mine, in the Island of Anglesea, which proved exceedingly remunerative for a long term of years, consisted of this cuproso-ferric sulphide alone; and so great was the mass of ore, that huge caverns, extending through the Parys Mountain in all directions, remain to attest the bulk of the ores which were removed during the period of the mine's prosperity. In foreign parts also there are several equally remarkable deposits of this particular ore. That of Rammelsberg, in the Harz Mountains, is believed to have been worked uninterruptedly for the last 900 years. The term lode would be equally inapplicable in this case, for the mineral forms a solid mass, increasing in width as you descend from the surface, so that the supply seems to be practically illimitable. It is not only of value for the copper it contains, but it supplies the material for the immense sulphuric acid manufactories of Oker.

Pomaron and some other places in Spain and Portugal have similar massive deposits of this ore, which are quarried and sent to Newcastle in large quantities for the same purpose as mentioned in Article XI. of "Chemistry Applied to the Arts." The mines of Cobre, in the island of Cuba, are of a similar character; and those of Fahlun, in Sweden, also contain very large masses of this same ore, associated with other valuable minerals.

The oxides are commonly distinguished as the black and red oxides, and have the constitution of CuO and Cu_2O respectively. They rarely occur in large masses, but are generally more or less mixed with other ores; wherever they do occur, however, they greatly enhance their value, on account of the large relative proportion of metal which they contain, the theoretical per centages, according to the above formulæ, giving 79·8 of copper for the black, and 88·8 for the red oxide.

The carbonates, however, are to be had in much larger quantity, and they form a considerable proportion of the rich ores which are imported from abroad. In addition to the Siberian malachite, which has been already referred to as an ornamental article, the green carbonate of the chemical constitution, $CuCO_3CuH_2O_2$, was the prevailing ore in the celebrated Burra Burra mines of South Australia, from which nearly three-quarters of a million's worth of ore was raised in the first five years that the mine was worked. The same kind of ore is found in Western Africa and other parts in large quantities. It should contain theoretically 57·4 per cent. of metal. The blue carbonate, or azurite, contains a double portion of the $CuCO_3$, and yields, when pure, 55·2 per cent. of copper. It is, however, not so commonly diffused as the green variety.

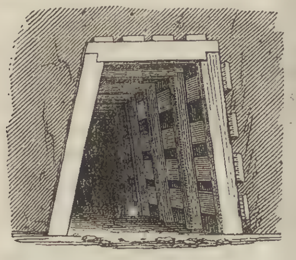


Fig. 14.—TIMBERS SUPPORTING WALLS OF LODE.

Copper also occurs sometimes in the metallic state, when it is called "native copper." The largest masses that have been known to exist have been found on the northern shore of Lake Superior; one of these masses is estimated to weigh 500 tons. The advantage of finding such riches as these is not, however, altogether without its drawbacks, as there is much difficulty in removing such huge pieces of metal. Of course, they are not unmixed with stones of quartz or other minerals, which render it difficult to reduce them to fragments by means of chisels, while on the other hand, the metal being tough in its nature, cannot be removed by blasting, as the ores can. The native copper, moreover, requires subsequent treating, as it contains other ingredients besides earthy matters, and not unfrequently other metals, which must be separated in order to produce a pure article.

The special instances which have been cited are sufficient to indicate the general abundance of copper ores in different parts of the world, but however rich they may be, they compete with difficulty with the comparatively poor ores of this country; and the question of supply is one much more nicely balanced than would appear at a cursory glance. Many of the Australian mines, for instance, including even the celebrated Burra-Burra, were closed on the rise in the price of labour when the gold discoveries in those colonies took place; a moderate advance in freights would render many other foreign mines no longer remunerative; while, on the other hand, there are many mines in Cornwall, now being carried on at a loss, which would yield a profit were only a slight advance in the copper standard to take place. Speculations, however, as to the probable course of prices in the future are worse than useless in respect of an article which can be supplied to a greater or less extent by almost every country on the face of the globe.

Let us turn to what has to be done to the ore on its arriving at "grass," or in other words, at the surface. Copper ore is not so intimately mixed with the gangue as tin, so that the pieces which are too poor to be worth smelting can readily be picked out. This is done by young girls at an almost nominal rate of wages, and the *deads*, as the waste is called, are thrown on one side. The larger lumps are broken up—*spalled* or *cobbed*—by women, lest there should be any valuable ore inside the mass, or to detach the ore from a superfluity of worthless stuff, or *dredge*. It is then picked over by the elder girls, who separate the ore, called *prills*, from the rest, and at the same time break up the mineral with a hammer of a particular form, termed a bucking-iron, until it is reduced to pieces not exceeding the size of a filbert nut. In some of the larger mines this is done by passing the prills between a pair of rollers revolving in opposite directions, and which are worked either by steam or water power. It is then *jigged* or *buddled* by being agitated under the surface of water, so that the smaller fragments of spar and other earthy material may be removed, and the ore, which is of greater specific gravity, remains behind in a clean state.

When a very large quantity of ore is raised it is found economical to lift the ore from the shaft to an elevated platform, and discharge it from the kibbles or boxes over a series of screens having the meshes of different widths, so that the ore may at once be separated into three sizes; the largest lumps which pass over the screens of four inches' mesh, are termed *rocks*, and have to be spalled; those which pass over the inch and a half screens are classed as *roughs*, and pass at once to the buckers, or if they are to be crushed by machinery, are only picked over first; the rest constitute the *smalls*, which are at once jigged under water on a sieve of one half-inch mesh, and those portions which do not pass through the sieve are added to the roughs previously described.

When the ores are dressed they are made up into piles, from which samples are taken and given to the representatives of each of the smelting works that they may make their assay preparatory to the ticketing day, the mode of sale of copper ore being similar to that of black tin. Each sample contains a pound and a half of ore. The processes required for a proper assay of copper ore are much more complicated than those of tin ore, for which reason fuller details must be given. The plan to be adopted depends materially upon the chemical constitution of the ore which has to be dealt with, and the proportion of foreign matter included in it. That the latter must exercise a considerable influence is sufficiently evidenced by the fact that the average samples of British ores only contain about eight per cent. of metallic copper.

The oxides and carbonates are most readily assayed; and more especially so when they contain no other foreign metal than iron. These are considered first-class ores. A certain quantity is finely pounded in a mortar, carefully weighed, and mixed with about three times its weight of a suitable flux. This mixture is put into a crucible, inserted in an ordinary assay furnace, and raised to a red heat. The crucible is left uncovered at first, and the door of the furnace is kept open until the contents of the crucible are fused, when they are both closed, and the damper drawn out so as to raise the furnace to its full heat. Within a quarter of an hour from this time the copper is reduced, when the crucible is withdrawn; and as soon as it has sufficiently cooled, the button of copper is taken out and weighed. If the ore be poor, it is desirable, after the first fusion, to add to the flux some sulphur and borax in equal proportions, to separate the regulus from the slag, and submit the former to a second fusion, until all the sulphurous acid is driven off. This gives a more accurate result than the single fusion, when there is a large proportion of earthy matter.

The common pyrites (cuproso-ferric sulphide) forms an ore of the second class. In treating this, the first object is to reduce the ore to a regulus, by fusing it with borax, which separates the earthy portions; and then to determine the amount of metallic copper in the regulus itself. This having been separated from the slag, is re-heated for the purpose of driving off all the sulphur, with which object it is at first only moderately heated in an open crucible, and kept stirred, so that all the contents of the crucible may be brought into contact with the air. After a sufficient quantity of oxygen has been absorbed to convert the copper into an oxide, the temperature is raised to drive off the remaining sulphur, and this is kept up until the whole of it is expelled. The oxide of copper thus obtained is lastly reduced to the metallic state, in the manner already described for the treatment of first-class ores.

The assayer has, however, very often to determine the value of samples that contain other metals besides those which have been already referred to. These mixed ores are generally ranked as third class. The principal ingredients against which he has to guard himself are arsenic and silenium. The powdered ore is first roasted in a furnace similar to that above

named, for the purpose of driving off the greater part of the sulphur. This is then roasted a second time with a flux consisting of borax, lime, and fluor spar; and then again with bitartrate of potash, borax, and chloride of sodium, at a high temperature, until the reduction of the metal is complete. Before weighing the button the slag should be carefully pounded in a mortar, in case any metal should come away with it, and if it does not appear clean and bright, it should be re-melted with a little nitrate of potash.

During these several processes there is some slight loss of metal, which becomes a very appreciable amount in an ore of low percentage; but as a matter of practice the loss thus sustained is about equal to that which is unavoidable in smelting on a large scale, and the result obtained is a very safe criterion for the smelter. Assays taken by the wet way, as it is called by chemists, are far more exact, but they indicate a percentage of copper which can never be realised in any smelting works.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

V.—CLASSIFICATION OF EXHIBITS (*continued*).

We have next to consider in what order the various nations taking part in these exhibitions should be ranged. To avoid the invidious office of attempting to place the countries according to political precedence, an alphabetical order has hitherto been adopted *in theory*, while *in practice* the most powerful have, under diplomatic influence, generally managed to secure the foremost place. If, however, an attempt were made to range the contributing countries according to their geographical position, in relation to climatal influences on their produce and resulting trades, we should get at an approximation to a natural classification by taking Holland for a starting-point on the Continent, as having a climate of average character with our own country; then following the coast-line round to the Mediterranean, striking upwards to the north, and returning in zigzag order to the south, we should pass from Russia on to Asia, from thence to Africa, Australia, and America South and North. Some such scheme might be elaborated that should not offend the prejudices or susceptibilities of the truly great Powers. It is a question as to how the colonies of our own and other countries should be placed, so as best to show the civilising influences of parent races upon acquired territories. Thus, it has been usual to range the various colonies in alliance with countries from which they are offshoots. Thus the produce, etc., of Canada was allied to English exhibits, and so on; but might it not be better to connect it with America? We should then have under America—the United States, British America, and so on.

ORDER OF NATIONALITIES FOR SUB-DIVISION OF CLASSES.

Great Britain.	India.	Brazils, and allied S. American Contributors.
Holland.	Ceylon.	British Guiana.
Belgium.	China.	Dutch "
France.	Japan.	French "
Portugal.	etc.	Ecuador.
Spain.		Columbia.
Italy.	Marocco.	Venezuela.
Switzerland.	Algeria.	
Austria.	Tunis.	West Indies.
Germany.	Egypt.	
Denmark.	Natal.	Central America.
Norway.	Cape Colony.	Mexico.
Sweden.	etc.	United States.
Russia.		Alaska.
Turkey.	Australia.	British America.
Asia Minor.	Tasmania.	
Persia.	New Zealand.	
Siberia.		

The idea of arranging the contributions to an international exhibition according to the scheme here defined seems, I find, to have originated with the Society of Arts, for at a special meeting of the Council held on Wednesday, the 14th of April, 1861, it was "Resolved—That the first of these exhibitions ought not to be a repetition of the Exhibition of 1851, which must be regarded as a special event, but should be an exhibition of works selected for excellence, illustrating especially the progress of industry and art, and arranged according to classes, and not countries."

In consequence, however, of the opposition expressed to this common-sense suggestion, by the representatives of influential Continental countries, this resolution was not carried out, and the system of courts and departments was again adopted in 1862; and at the Exhibition of 1871, neither one system nor the other was adopted, but a mixture of the old plan with the new ideas, which led to "confusion worse confounded." It is, however, to be hoped that for any future exhibitions the system announced for 1871 will be insisted on and carried out with firmness. It is a question whether this system might not in certain cases be modified at the discretion of the superintendents of classes and their committees of selection—viz., as to whether sub-divisions according to countries might not be applied with advantage to the groups constituting a class. Thus, in the class representing philosophical instruments, much valuable information might be obtained by bringing the telescopes, with the systems of mounting astronomical instruments in various countries, into one group, so as to facilitate direct comparison as to points of construction, price in relation to workmanship, etc.; so with microscopes, their accessories and methods of mounting objects; while, on the other hand, in the educational department, it would be better to let each country illustrate in the most complete manner attainable its special system of education, and appliances for teaching all branches of knowledge, whether adapted for the infant school or the college, and the scientific appliances of the educational department might form a connecting link with the class representing philosophical instruments, etc., of a higher order.

It was settled by the Commissioners that in the 1872 and following exhibitions the makers of certain *parts* of an article might become exhibitors: thus, a watch is made up of many parts, which are manufactured by distinct branches of the trade; so, workmen who make watch-springs, wheels, fusees, escapements, dial-plates, cases, and the numerous parts that make up the whole of which a watch is constituted, may display their skill independently of the "watchmaker" who puts together or sells the perfect instrument. So in the fine-art department, "The artist may exhibit a vase for its beauty of painting, or form, or artistic invention, while a similar vase may appear in its appropriate place among manufactures on account of its cheapness or the novelty of its appearance," for "it is intended that these exhibitions shall furnish the opportunity of stimulating the revival of the application of the artist's talents, to give beauty and refinement to every description of object of utility, whether domestic or monumental."

Notwithstanding the increase of objects that might by this rule be exhibited, all danger of overloading the galleries was avoided by continuing the judicious system adopted in 1871, of only admitting such articles as had passed under the supervision of a committee of selection for the group under which they were classified; and further, by the equally judicious regulation that exhibitors would only be allowed "to send one specimen of each kind of object they manufacture," thus preventing a repetition of those shop-window-like displays of duplicate pairs of boots, shoes, pickle-bottles, jam-pots, mustard-cans, etc., that certainly could only be regarded as good mediums for advertising.

Valuable space would be saved at all exhibitions by providing the glass cases and stands necessary for the display of objects, and the appearance of the galleries would be greatly improved by the uniformity of aspect and design. The same applies to the supply of motive power for machinery, etc., or the use of gas, fire, steam, or water.

The method of making the exhibitors supply the necessary matter for the catalogues, and the catalogues in turn furnishing the materials for the labels to be attached to each article exhibited, is a novel principle that strongly recommends itself.

In the forms sent to manufacturers invited to contribute to the Exhibition of 1871 was the following regulation:—

XII. To every object, when exhibited, will be attached a label, prepared by Her Majesty's Commissioners, which will contain the following particulars:—

1. The name of the object.
2. The exhibitor's name.
3. His address.
4. The name of the designer or actual maker (*if the exhibitor pleases*).

5. The reasons why it is exhibited, such as its
   Novelty,
   Design,
   Excellence,
   Cheapness.
6. The price.
7. Any explanations, such as the materials of which it is composed. The purpose for which it is intended.

It will be found, however, that in practice the details were confined to the name of object, price (when given by the exhibitor), and the exhibitor's name, which, as a rule, would be found sufficient, if supplemented in the catalogue by an index of contributors, with their addresses and record of honours acquired at previous exhibitions, and the biographical notices of all artists and producers announced in the preface to the catalogue of the Exhibition of 1871. Thus, if Professor L. Knaus contributed many pictures, and they were *distributed*, it will be seen by the annexed example that *the repetition* of the bibliographical matter would add materially to the bulk of the catalogue, when such a system was applied to other exhibitors.

7. A Shoemaker's Wife, with her Child and an Apprentice, watching a Mouse in a Trap ... ... *Prof. L. KNAUS.*
Germany. 140, *Duisburger Strasse, Dusseldorf.* Born at Wiesbaden; pupil of the Dusseldorf School of Art; Member of the Bavarian Order of Maximilian; Officer of the Legion of Honour; Knight of the Order of the Red Eagle, 3rd Class; Knight of the Order of Francis Joseph; Knight of the Order of Leopold; Knight of the Order of Adolphus of Nassau; Member of the Academies of Berlin, Vienna, Stockholm, Amsterdam, Munich, Antwerp, Brussels. First Class medal, 1855; Grand Prize, 1867.*

But if such details were given in the Index, once would suffice for all, and the information would be useful to the public and the exhibitor alike. Thus—

INDEX.

Name.	*Biographical Notice.*	*Number.*
Bonheur, Mdlle. Marie Rosa	. . .	1141, 1142, 1326, 1327

France. *By, Commune de Thomery, Seine-et-Marne.* Born at Bordeaux; pupil of R. Bonheur, her father: First Class Medal, 1855; Chevalière of the Legion of Honour, 1865; Second Prize, 1867.

While in the body of the catalogue this artist's works would stand thus:—

EAST GALLERIES (ROOMS XIX. AND XX.), FRANCE.

Name.	*Subject.*	*Contributor.*
1141 Bonheur, Marie Rosa .	"Returning from the Mill."	*Mr. F. T. Turner.*
1142 Bonheur, Marie Rosa.	"Forest of Fontainebleau."	*Mr. F. T. Turner.*
* * *	* *	* *
1326 Bonheur, M. Rosa. .	"A Family of Deer."	*Mr. H. F. W. Bolckow, M.P.*
1337 Bonheur, M. Rosa. .	"Sheep"	*Baronne d'Erlanger.*

As a sample of the labels prepared from such a catalogue the annexed may be given, with the statement that the labels indicate by coloured borders the country from which the object comes. Thus the border for Austria is *orange;* Belgium, *dark blue;* China and Japan, *magenta;* Denmark, *chocolate;* France, *green;* German Empire, *black;* Greece, *full brown;* Italy, *pearl grey;* Netherlands, *brown;* Norway and Sweden, *light blue;* Russia, *pale grey;* Spain, *lemon;* Switzerland, *grey;* Tunis, *fawn;* Turkey, *lavender;* United States, *blue;* United Kingdom, India, and Colonies, *red.*

CLASS X.

6696 Collection of Geometrical Models, Price £7. *J. Schröder.*

GERMAN EMPIRE.

Much discussion and ill feeling has arisen on the part of English exhibitors as to allowing the annexes attached to certain foreign countries to be used as mere bazaars, not merely for their manufactures admitted to the several classes, under the approval of the committee of selection, but for the sale of goods generally, a privilege not accorded to or desired by English contributors, who feel aggrieved at an undue advantage being accorded to foreign traders, whose home ideas are of a conservative character—a privilege not discovered till after the exhibition had been open some months.* It is stated in reply to this charge, that when the representatives of the French manufacturers were informed that the custom of giving prize medals was to be discontinued, they declared that if they were expected to exhibit "*without profit or glory*" they must decline to enter the field; so, as a sop in the pan, the permission to sell in the annexes was accorded. All attempts to turn international exhibitions into bazaars for open touting or selling ought to be discouraged to the utmost; but there can be no objection to the appointment of official agents for the several classes, under such regulations that the interests of both English and foreign exhibitors shall be fairly provided for, and the convenience of the public considered. Country and foreign visitors, with little time at their disposal, would fully appreciate the advantage of being able to visit an office within the building, where they could give their commissions for objects only obtainable at the close of an exhibition, or to secure duplicates of such as could be supplied at an earlier date. So far for the question of "profit;" for undoubtedly the object of these displays is to encourage progress in manufactures and art.

As to the question of "glory," or the honours to be acquired by exhibitors, the resolve on the part of H.M. Commissioners to dispense with the award of prizes, shelves a difficulty that has been fully discussed; but if the distinction of admission is to be regarded as an honour of equivalent value, would it not be policy to give the promised certificate in the form of a bronze *medal,* to which a conventional value is attached that never pertains to lithographic documents. The issue of special untransferable personal season tickets to the exhibitors can only be regarded as a decision founded on sound policy, for it is only fair that those who contribute to a feast should find a place thereat, without being charged for the privilege by those who preside at it, as was the case on former occasions. Moreover, it is only right that exhibitors should have the opportunity of seeing that the articles which they exhibit are kept properly displayed, and in good order, without being fined in the shape of charges for admission, for by the constant vibration articles often get shaken into positions ill suited for their proper display, or get dimmed by greater or less deposits of dust, which is almost sure, in the course of time, to find its way into cases, even of the best make.

In connection with the question of dust, displacement, and re-arrangement, I would point out the necessity for the superintendents of classes or their assistants being present to meet exhibitors at set times and days, if the Commissioners undertake the entire charge or keeping of the exhibits, as introduced in 1871. In many cases I saw labels in positions where they could not be read, and trays, etc., placed one over the other, in a provisional manner, consequent upon the hurry to get things into place for the opening, that were never put right during the entire term of the exhibition—matters that would have been immediately corrected had provision been made for superintendents and exhibitors coming into periodical contact. In the Fine Arts Gallery a life-sized picture of a female in the costume of Eve *before* the fall, through a blunder in the numbering, was described in the catalogue as a "*Portrait of the Artist,*" much to the horror of many maiden ladies, who could hardly believe it possible that things had come to such a pass with the order of strong-minded women, that any member of the Bohemian sisterhood could *coolly* depict herself while "holding, as it were, the mirror up to Nature," and then having the production thus catalogued. The mystery would have been sooner solved had artist and superintendent come into contact, for it ultimately proved that the proper designation of this subject was "*Truth*" (the *bare* truth it may be assumed), and the artist of the masculine gender.

The same rule holds good in regard to the "Committee of Selection," as, to my personal knowledge, many objects tendered for admission were rejected, which would have been (and were ultimately) admitted, had an opportunity been afforded for

* See "Announcement of the Forthcoming Series of Annual International Exhibitions," etc., Offices of H.M. Commissioners, 1870.

* The dissatisfaction thus caused was in fact a weighty reason for the discontinuance of the Annual Exhibitions after 1874.

exhibitor and committee coming into contact, for it frequently happens that experts *do not intuitively* recognise novel points of construction, ingenuity of arrangement, or the value of cheaper processes for producing known results, till a personal explanation or demonstration has been given; and it is but human nature to assume airs of infallible perception when placed in positions to dictate *ex cathedrâ*.

Official reports on exhibitions are valuable alike to exhibitors and the public, if written by those completely conversant with the range of subjects they undertake to report on. When there is a sub-division of labour, there should be a clear understanding between the staff of reporters, as to the ground each intends to occupy; for in some of the reports for 1871 I notice that, while some attempt to pass judgment upon subjects with which they are evidently unfamiliar, though conversant with the details of other groups, others, through want of preconcerted arrangements, clash with the ground covered by reporters on allied groups. Such matters of detail ought to be arranged on a satisfactory basis for future exhibitions.

CHEMISTRY APPLIED TO THE ARTS.—XVI.

BY GEORGE GLADSTONE, F.C.S.

ALCOHOLS AND ETHERS.

It is not intended in this article to treat of the manufacture of the various spirits having alcohol for their basis which are simply used as exhilarating drinks, amongst which brandy, gin, rum, whisky, etc., are the most familiar preparations—but rather to speak of alcohol in its more innocent, nay, useful applications.

Absolute alcohol is a compound of carbon, hydrogen, and oxygen, in certain definite proportions, the most familiar being what chemists would distinguish as ethylic alcohol, or hydrate of ethyl, C_2H_6O. Another alcohol, of not uncommon occurrence in the arts (as it is much cheaper than the preceding, being free of duty), is that derived from methyl, CH_3, having the formula CH_4O; and a third, the amylic, $C_5H_{12}O$. It will be seen, in comparing these three formulæ, that they bear a definite relation to one another—beginning with the hydrate of methyl as the lowest in the series, the higher terms increase by the addition of two atoms of hydrogen to each one of carbon. It is unnecessary to give the intermediate and higher terms, of which there is a long series, as those above-named are the most important. It is worthy of remark that each of the alcohols may be converted into an acid by the replacement of two atoms of hydrogen by one of oxygen; C_2H_6O becoming in that case acetic acid, $C_2H_4O_2$, as described in the last article; the hydrate of methyl becoming formic acid, CH_2O_2, and that of amyl becoming valerianic acid, $C_5H_{10}O_2$, and so on throughout the whole series.

The sweet vegetable juices or extracts are liable to undergo fermentation, and it is well known that powerful and exhilarating liquors are derived from them. They all contain alcohol to a greater or less extent, to which ingredient these special characteristics are due. The juice of the grape was perhaps the first source of alcohol, and so it obtained in this country and some others the name "spirit of wine." It is now however very largely manufactured from a great variety of substances, the material from which it is made often imparting to it a peculiar smell or flavour, which has led to a specific name being given to such spirit. Thus, the juice of the sugar-cane produces rum; rice, arrack; etc. Malt made from any kind of corn will yield a spirit, and on the Continent of Europe potatoes, mangold, beetroot, carrots, and many other roots of a similar character containing saccharine matter, are mashed up and fermented to make brandy or other spirituous liquors.

The character of the transformation will be best understood by comparing the chemical constitution of the substances. Grape sugar (or glucose, which is the scientific term) consists of $C_6H_{12}O_6$ when all the water which is usually in combination with it is driven off, and under the action of the vinous fermentation it separates into two portions; the result is the formation of two atoms of alcohol, $2C_2H_6O$, and two atoms of carbonic anhydride, $2CO_2$, which will be found to make up exactly the formula of the original grape sugar.

Alcohol has such an affinity for water, that it is extremely difficult to keep it absolutely pure, even after it has once been made so. We will suppose that the distiller has produced the raw spirit, which, when duly doctored, may constitute either gin or brandy; it will be found on examination to consist of C_2H_6O + an indefinite quantity of water. To render it absolute, it is usually distilled over and over again several times, by which means it increases in strength each time; but this process alone will not thoroughly effect the separation of all the water, however often it may be repeated. About 9 per cent. of water is found still to remain mixed with the spirit after carrying fractional distillation as far as possible. The final process is therefore varied, and the last distillations are made in the presence of some carbonate of potassium or chloride or hydrate of calcium, which, having a greater affinity for water than even the alcohol itself, takes up the moisture and only allows the anhydrous spirit to pass over from the retort. If quicklime be used, the retort should be about two-thirds filled with it, and then sufficient alcohol poured in to cover it over; the lime will soon become slaked by the absorption of the water contained in the alcohol, which can then be separated by distillation. This is repeated several times, until all the water is removed; and the alcohol, being thus rendered absolute, must be carefully preserved from contact with the air, or fresh moisture will be absorbed.

As alcohol is considerably lighter than water, the purity of it can be tested with great accuracy by ascertaining its specific gravity. The pure spirit will not exceed 0·795 at the ordinary temperature of the air. Tables have been constructed showing at a glance the relation of the specific gravity to the percentage of alcohol at given temperatures, so that all that need be done is to ascertain these data as to any specimen in question, and the strength of the spirit will be known at once.

Another mode of determining the same point is by the use of the hydrometer, that of Sykes' being the one approved by our Government, and generally used in calculations for the Revenue. Proof spirit, as it is called, is the standard for the assessment of duty; and is of such a strength that its weight shall be 12-13ths of that of water at a temperature of 51° Fahrenheit. Taking, therefore, this as the basis, the hydrometer is so constructed that by the addition of weights to the portion below the bulb it shall just float in the spirit, the part above the bulb being graduated so that any one can read off to a nicety the precise point of immersion; and then, by reference to the calculated tables, the exact strength of the spirit above or under proof is at once ascertained. Thus, at a temperature of 60° the specific gravity of proof spirit is 0·9186; and the relative proportions by weight of alcohol and water will be found to be 49·5 of the former to 50·5 of the latter.

A third plan of determining the strength is by ascertaining the boiling point, which naturally becomes more and more assimilated to that of water, 212°, as the quantity of this ingredient augments, the boiling point of pure alcohol being very much lower. The following table will show the effect of a reduction in the strength of the spirit in this respect:—

Percentage of Alcohol.	Boiling point, Fahrenheit.
90	174·2°
80	175·3°
70	177·6°
60	179·4°
50	181·6°
40	183·4°
30	187·2°
20	192·4°
10	199·2°

It will readily be inferred that these tests are only applicable to such spirits as contain no other ingredient; for instance, those which are sweetened will have a greater specific gravity, dependent upon the amount of saccharine matter held in solution, and the boiling point will also vary according to the nature and proportion of the other ingredients.

Pure alcohol exercises many important functions in chemistry. By mixing it with snow an intense cold can be produced; and it is almost impossible to freeze it, as it may be reduced to 150° below zero without congelation, on which account it is used in the manufacture of thermometers which may be required to register very low temperatures. When diluted with water it is a powerful stimulant; but strong alcohol is highly injurious to the animal system, as it withdraws the water necessary to the

healthy condition of the tissues, and coagulates the albuminous portions. It is an excellent solvent for all kinds of resins, fats, and essential oils, and as such is used in the preparation of the best varnishes, soaps, and perfumes. Reference has already been made to this use of it in Article VIII. Many other substances are also soluble in alcohol, which are not at all affected by water. It is likewise used in the preparation of many compounds which are of much value in medicine, especially of the various anæsthetics, which are now so extensively employed.

Chloroform, for instance, is yielded by the distillation of alcohol along with some chloride of calcium. The proportions required are 6 parts of the latter to 1 of alcohol containing 84 per cent. of spirit, and 30 parts of water; or it may be made from 8 parts of the chloride of lime, 1 of quicklime, 1 of alcohol, and 40 of water, which will yield a quantity of rectified chloroform equal to one-third of the alcohol consumed. The resulting liquid will have the constitution $CHCl_3$, the effect of which in producing insensibility to pain on being inhaled is well known. For this purpose it is of the utmost importance that it should be as pure as possible, especially as the ingredients most likely to find their way into it are not easily detected, except by the injurious effects they produce upon the individual. It is a highly volatile liquid, though at the same time a very heavy one, having a specific gravity of 1·49 at 60°. This circumstance affords a ready means of detecting any adulteration, either with alcohol or ether, in both of which it is soluble; in such case the weight of the liquid would be greatly reduced, as there is such a wide difference between their specific gravities and that of chloroform. It possesses in a very high degree the power of preserving animal matter from putrefaction.

Chloral, the hydrate of which has recently been introduced as a medicine, and is now very generally administered for the purpose of inducing sleep, is another product of alcohol and chlorine. The most direct process for its preparation is to pass dry chlorine gas into absolute alcohol. It is of the greatest importance that both of the ingredients shall be free from admixture with water, and as each has a great affinity for it, much care must be taken in order to ensure its absence. The gas is best dried by passing it through some strong sulphuric acid, or over chloride of calcium. At the commencement of the operation the alcohol must be kept cool, by exposing the outside of the glass vessel which contains it to the action of cold water, so as to prevent the contents from taking fire; but as the absorption of the chlorine increases, the mixture must be heated nearly to the boiling point. It ultimately becomes thick and syrupy; and after standing a while it solidifies into a soft crystalline mass, which is the hydrate of chloral. This substance is then melted, and agitated with four to six times its bulk of sulphuric acid, when the pure chloral will separate and float on the top. It is finally distilled over slaked lime, for the purpose of removing any hydrochloric acid which may have been formed in the course of the operation. Pure chloral is a thin, pungent, colourless oil, of a specific gravity of 1·5, which boils at 203° Fahrenheit.

Alcohol is also the foundation of all the different kinds of ether which are used in pharmacy or otherwise. The description in most common use is often called sulphuric ether, because the acid bearing that name is used in its manufacture; but it is a very misleading title, as there is no sulphur whatever in its composition. The oxide of ethyl is the scientific name, as it consists of $2C_2H_5\,O$. The reason for adopting this name will appear more plainly presently, when other ethers come to be considered, as it will then be seen that the one atom of oxygen is capable of being replaced by other elements or combinations, and that the $2C_2H_5$ represents ethyl itself, a gaseous substance, which on burning yields a brilliant light.

There are some general characteristics common to all this series of products. They are highly volatile inflammable liquids, of a very light specific gravity, with a fragrant odour, and having the faculty of producing numbness even to complete insensibility when inhaled in considerable quantity. They will mix with alcohol in any proportion, but not with water, except to a very slight extent. They are valuable as solvents, most of the articles soluble in alcohol being also capable of being dissolved by ether, and in some cases more readily than in the former.

The ordinary plan of making the oxide is to distil over a mixture of sulphuric acid and alcohol. If the relative proportions are as two to one, the mixture will boil at about 250° Fahrenheit, gradually rising to 280°, and the vapour when condensed will be found to consist of a mixture of ether and alcohol, the ether greatly predominating as it reaches the higher temperature; as the boiling point rises from that to 320°, ether will come over mixed more or less with water; and if the distillation be carried beyond that stage the boiling point will rise still higher, but the contents of the still will be converted into olefiant gas and sulphurous acid. The object of the manufacturer is therefore to keep the boiling point at about 300°, which is done by constantly keeping up the supply of alcohol, so that the relative proportions may not materially vary.

Hydrochloric ether, or more exactly chloride of ethyl, C_2H_5Cl, may be made either by saturating absolute alcohol with hydrochloric acid gas, or by distilling alcohol with one of the chlorides, such as common salt. It is used in medicine generally in combination with alcohol.

Nitric ether, $C_2H_5NO_3$, is also used for a similar purpose to a considerable extent.

SEATS OF INDUSTRY.—XXIV.

ST. LOUIS.

BY WILLIAM WATT WEBSTER.

In 1762 M. d'Abbadie, the Director-General of Louisiana, granted to a company of merchants, of whom Pierre Liqueste Laclede was the leader, the exclusive privilege of trading with the Indians on the river Mississippi, along with permission to settle on any spot in the valley of the "Great Waters" they might choose to select. The qualities desiderated in a site by these pioneers of commerce were facilities for carrying on the fur trade, and natural strength of position for defence against the Indians. It was because it possessed both of these advantages in a high degree that Laclede and his companions, after a careful exploration of the territory, established themselves, on the 15th of February, 1764, at the place afterwards occupied by the important commercial city of St. Louis. To the trappers the confluence of the different rivers in the immediate neighbourhood was a great attraction, as it afforded a comparatively easy means of communication with the great hunting-fields. At first but four houses were built, and the settlers were proportionately few. On the 11th of August, 1768, a Spanish officer, named Rious, with a company of Spanish troops, took possession of Laclede's settlement and Upper Louisiana, as the district was then termed, in the name of the king of Spain, under whom it remained until 1801, when it was restored to France. It was sold to the United States in 1803. By 1770 the number of settlers at St. Louis had increased to forty families, and a small garrison was stationed there for its protection. In common with other settlements on the Mississippi, Illinois, and Wabash rivers, St. Louis was threatened with destruction in 1780 by a British force, but this disaster was averted through the energy of General George Rogers Clark. Some statistics of the fur trade of St. Louis for the fifteen years immediately preceding 1804 have been preserved, which show that at that early date it had reached considerable dimensions. The average annual value of the furs collected at the port during that period amounted to 203,750 dollars, and the number of skins were—150,000 deer skins, 36,900 beaver skins, 8,000 otter skins, 5,100 bear skins, and 850 buffalo skins. In 1804 the population was estimated at between 1,500 and 2,000 persons, one-half of whom were absent during the greater part of the year on hunting expeditions, either as trappers or as voyageurs—the latter name being given to the boatmen who brought home the skins. In 1813 the first brick house was erected; and in 1817 the first steamboat arrived at the port.

St. Louis made little progress in population during the first two decades of the century, its inhabitants only numbering 4,598 in 1820; but two years later it was chartered as a city under the title conferred on it by Laclede, in honour of Louis XV. of France. About the year 1825 the growth of Illinois became marked, and between that year and 1830 St. Louis received considerable additions to its population from that State. It was at this period that the foundation of the trade between Illinois and St. Louis was laid—a connection that has contributed largely to the prosperity of the latter, and that still constitutes an important branch of the commerce of the port.

By 1829 the keel boats had entirely disappeared from the river; and a steamer, named the *Yellow Stone*, ascended to the Great Falls about the same date. During the ten years between 1820 and 1830, however, but little increase took place in the population, which in the latter year only numbered 6,694; but in the succeeding decade it was much more than doubled, having in 1840 reached 16,469. It was then that the extraordinary rapidity of growth that has distinguished the city, even among American towns, first distinctly showed itself. About this time extensive warehouses began to be erected near the brink of the river, which is the oldest part of the city, and is still the centre of its commerce. Up till the year 1849 a large proportion of the houses in St. Louis were built of wood; but at that date a great fire occurred, that destroyed a considerable part of the city, and the new houses erected were chiefly constructed of a limestone found in the neighbourhood, which, though soft when first taken from the quarries, becomes hard and durable after it has been exposed for some time to the action of the atmosphere. The returns of the population for 1850 showed that St. Louis contained 75,204 free citizens and 2,650 slaves, making a total of 77,850, or nearly five times as many inhabitants as in 1840. Of these the larger half, or 40,414, were natives of foreign countries; 23,774 having been born in Germany, 11,257 in Ireland, 2,933 in England, and 2,450 in other foreign countries. The natives of the United States resident in the town at that date numbered 37,436. During the succeeding two years the population of the city and suburbs was found, by a local census that was taken in 1852, to have increased by about 20,000.

For some time previous to the date last mentioned St. Louis had been the principal emporium of the countries on the Missouri and the Upper Mississippi. The value of the produce brought to the quays of the city in 1849 was estimated at considerably more than 10,000,000 dollars; and at the same date the shipping belonging to the port, consisting mostly of steamers, reached an aggregate of 32,225 tons. Three years later the quantity of flour annually ground and dressed at the extensive mills in the city and its vicinity amounted to 393,184 barrels; and it was estimated that the flour-mill machinery was capable of producing 3,000 barrels per diem. In 1852 no fewer than 3,184 steamers arrived in the port; and, according to the customs returns, 37,861 tons of shipping, of which 32,646 tons represented steam-vessels, were owned in St. Louis. The official statistics for 1855 give the number of the inhabitants of the city proper in that year as 97,642, of whom 94,686 were free; and it is estimated that the entire population of St. Louis and its suburbs at this date amounted to nearly 120,000. Two items from the trade returns for 1859 will serve to some extent to show the nature and dimensions of the commerce of the city at that date. The produce of the flour-mills during that year amounted to 873,506 barrels, or nearly three times the quantity turned out only seven years before. In the same year there were received into St. Louis 53,174 hogsheads, 9,186 barrels, and 6,693 boxes of sugar. The value of the furs brought to the port in the following year was estimated at 549,422 dollars, of which amount 340,000 dollars represented buffalo skins, 85,000 having passed through the market. By 1852 lard and linseed oil had become important items in the produce of St. Louis, 5,000 barrels of the former having been exported in that year. In 1860, however, no less than 30,000 barrels of lard were manufactured, and the number of hogs slaughtered in St. Louis alone in that year was calculated at 78,000. The packing and shipping of pork, beef, and hams had also by this time become a very extensive branch of trade, and employed a large amount of capital and a large number of persons. Tobacco manufacture was then also carried on in the city on an extensive scale by about a dozen establishments.

But the manufacture of iron surpassed and still surpasses all the other industries of St. Louis, both as regards the amount of capital invested and the number of persons employed in it. The district surrounding St. Louis is remarkably rich in mineral resources, comprising iron, coal, lead, copper, and marble, and its mineral wealth has constituted an important element in its prosperity. Among the most striking natural objects in the State of Missouri, of which St. Louis is the principal city, although not the capital, are its two hills, composed of micaceous oxide of iron, situated in St. François county. One of these hills, called "Iron Mountain," rises 350 feet above the plain, and is one mile and a half broad at its summit; the other, called "Pilot Knob," is one mile and a half in circuit at the base, and 308 feet high. Vast quantities of the ore from these mountains are brought to St. Louis, and there smelted, and manufactured into stoves, railway machinery, and locomotive and stationary engines. In 1858, 17,565 tons of pig iron from Iron Mountain and Pilot Knob were landed at the port; in 1859 the quantity rose to 16,250 tons; and in 1860 to 19,700. About 50,000 tons of iron from other points were at that time annually worked up at St. Louis. The shipping owned, enrolled, and licenced at the port in 1860 amounted to 64,683 tons; and the number of steam-vessels that arrived at St. Louis in that year numbered 4,371, representing a total burden of 1,120,039 tons. During the year 1860 nearly 2,800 buildings were erected in the city, at a cost of about 7,500,000 dollars, and at that date the population amounted to 151,780, of whom about 1,500 were slaves. There were then fifty-three periodicals and newspapers published in St. Louis, including eleven daily newspapers, issuing weekly editions; three tri-weeklies, twenty-four weeklies, four semi-monthly publications, and two quarterlies. At the present time the population of St. Louis, notwithstanding the losses of men and money in the Civil War, is calculated at over 200,000.

St. Louis is admirably situated on an elevation, consisting of two plateaux of limestone formation, the one about fifty feet above the floods of the Mississippi, and the other about sixty feet. It is about eighteen miles below the mouth of the Missouri, and nearly 200 miles above the mouth of the Ohio. By the river the distance between St. Louis and New Orleans—to which the navigation is always open—is a little over 1,200 miles. It is the capital of the judicial district and county of St. Louis, and is governed by a mayor and a common council, consisting of twenty members in addition to the mayor. The city covers an area of about sixteen square miles, but the thickly-populated part is only from two to two and a half miles in length, following the course of the river, and about one and a quarter miles in breadth. Portions of the town, however, extend nearly seven miles along the Mississippi, and nearly three miles from its right bank. The Upper Mississippi, the Ohio, the Missouri, and their numerous tributaries, afford connected and easy water communication, extending to about 8,000 miles, between St. Louis and vast regions extraordinarily rich in mineral, vegetable, and animal products. It is the principal seat of the American fur trade, and of the overland trade with Mexico. St. Louis is remarkably well built, the streets, for the most part, being sixty feet wide, and, with few exceptions, intersecting each other at right angles. Front or Levee Street, which runs along the river, is upwards of 100 feet wide; and the side next the Mississippi is occupied with a range of massive stone warehouses of imposing appearance. Among the public buildings in the city the most noteworthy are the City Hall; the Court-house, erected at an expense of half a million of dollars; the new Custom House and Post-office, which cost 350,000 dollars; and the central market buildings, which occupy the site of the old market and town-house. There are about eighty churches in St. Louis—the Methodists and the Roman Catholics being the largest denominations, and having each about an equal number of places of worship. The Roman Catholic cathedral, built in 1831, is a very handsome Doric structure, with a tower ninety feet high, surmounted by a spire. The Roman Catholics have also a university in St. Louis, called the St. Louis University, which was founded by the Jesuits in 1848 for the study of the classics and *belles lettres*: it has also a medical faculty. Between 100 and 150 students attend its classes. In the Washington University at St. Louis, incorporated in 1853, all the branches of study commonly included in a university curriculum, with the exception of theology, are taught. A German institute of science was founded in 1856. There are also in the city other colleges and schools for the higher class of education.

PRINCIPLES OF DESIGN.—XXVIII.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

HARDWARE.

HAVING considered metal work in its more costly branches, we come to the consideration of hardware; and I am glad that we have reached that part of our subject which deals with inexpensive materials, for they are those which must be generally employed, while works formed of the precious metals can be used

only by comparatively few persons. The object of art is the giving of pleasure; the work of the artist is that of giving ennobling pleasure. If as an artist I give pleasure, I to an extent fulfil my mission; but I do so perfectly only when I give the greatest amount of the most refined pleasure by my art that it is possible for me to give. If by producing works which can be procured by many I give pleasure, it is well that I do so; but if the many fail to derive pleasure from my works, then I must address myself to the few, and be content with my lesser mission. Education appears to be necessary to the appreciation of all art; the artist, then, is a man who appeals to the educated. If some persons, by their superior education, are enabled to appreciate art much more fully than those who are more ignorant, and can consequently derive much more pleasure from it than the less cultured person, it might then be desirable that the artist should address himself, through costly materials, to the few, for thereby he might be giving the greatest amount of pleasure. I always, however, like to produce works in cheap materials, for then I know that I form what is capable of giving pleasure to the poor man—if appreciative—who may possess it, as well as the rich.

In hardware we have two classes of work produced which appear to have little in common—the one class being characterised by a preponderance of excellence, and the other by the dominance of what is coarse and inartistic. The first class of work is that which is produced by what are termed ecclesiastical metal workers; the second consists of what is generally known as Birmingham ware.

It is an error to suppose that these so-called ecclesiastical—or mediæval, as they are sometimes called — metal workers produce only ecclesiastical and mediæval work. On the contrary, some of these men—and they are now many in number — devote themselves almost exclusively to domestic work, and most of them fabricate articles in all styles of art. If I wanted an artistic set of fire-irons, I should go to one of the ecclesiastical warehouses, for there I have seen many sets that my reason commends and my judgment approves; but I never saw a set produced for the general market that I liked; and the most artistic fenders, grates, and gas-fittings, in almost any style, are to be got at these shops. I do not mean to convey the impression that all things made at these ecclesiastical warehouses are good, and that all things of Birmingham (or Sheffield) manufacture are bad, for I have seen indifferent works in these mediæval shops, and I have seen excellent things from Birmingham—especially I might mention as good certain gaseliers produced by two Birmingham houses—but as a rule the works found in the mediæval warehouses are good, and as a rule the works in hardware produced by Birmingham and Sheffield are bad, in point of art.

It will appear monotonous if I insist that the materials of which works of hardware are formed be used in the easiest manner in which they can be worked, and that every article be so formed as perfectly to answer the end of its formation. Yet I must do so. Let us look for a common set of fire-irons, and we shall find that nine pokers out of ten have a handle terminating in a pointed knob. Now, as the object of this knob is that of enabling us to exercise force wherewith to break large pieces of coal, the folly of terminating this knob with a point is obvious. A poker is, essentially, an object of utility; it should therefore be useful. It is ridiculous to talk of a poker as an ornament; yet we find it fashionable now to have a bright poker as an ornament, which is obtrusively displayed to the visitor, and a little black poker, which is carefully concealed from view, reserved for use. I cannot imagine what people will not do for show and fashion, but to the thinking mind such littleness as that which induces women to keep a poker as an ornament must be distressing; and until persons who desire to be regarded as educated learn to discriminate between an ornament and an article of utility little progress in art can be made. If a poker is simply a thing to be looked at, then it may be as inconvenient as you please, for if it has no purpose to fulfil by its creation it cannot be unfitted to its purpose. The same remark will apply to shovel and tongs. If they are intended as works of utility, then their form must be carefully considered; but if they are to be mere ornaments I have nothing to say respecting them.

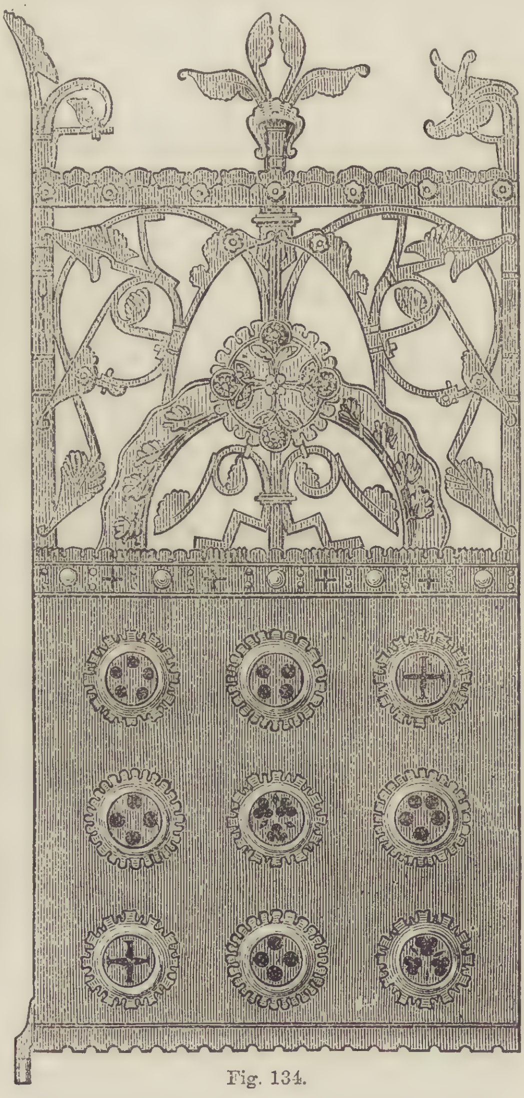


Fig. 134.

Utility and beauty are not inseparable; but if an article of any kind is intended to answer any particular end, it should be fitted to answer the end proposed by its formation; but after it is created as a work of utility, care must be exercised in order that it be also a work of beauty. With due consideration, almost every work may be rendered both useful and beautiful, and it must ever be the aim of the intelligent ornamentist to render them so.

Iron is capable of being wrought in various ways; it may be "cast" or "hammered," or cut or filed. "Casting" is the least artistic mode of treating iron; but if iron is to be cast, the patterns formed should be so fully adapted to this mode of formation that the method of working may be readily apparent. It is foolish to seek to make cast-iron appear as wrought-iron: cast-iron should appear as cast-iron, and wrought-iron as wrought-iron. Cast-iron is brittle, and must not be relied upon as of great strength; while wrought-iron is tough, and will bend under great pressure rather than break. Wrought-iron can be readily bent into scrolls, or the end of a rod of metal can be hammered flat and shaped into the form of a leaf, and parts can either be welded together or fastened by small collars, pins, or screws. One or two illustrations of good wrought-iron work by Skidmore, Benham, and Hart, we give in our engravings.

As an illustration of a simple railing, we figure one shown in the International Exhibition of 1862 (Fig. 133), which is in every respect excellent. Its strength is very great, yet it is quaint and beautiful. As it was shown it was coloured, and the colour was so applied as to increase its effect and beauty. If the student will carefully devote himself to the consideration of

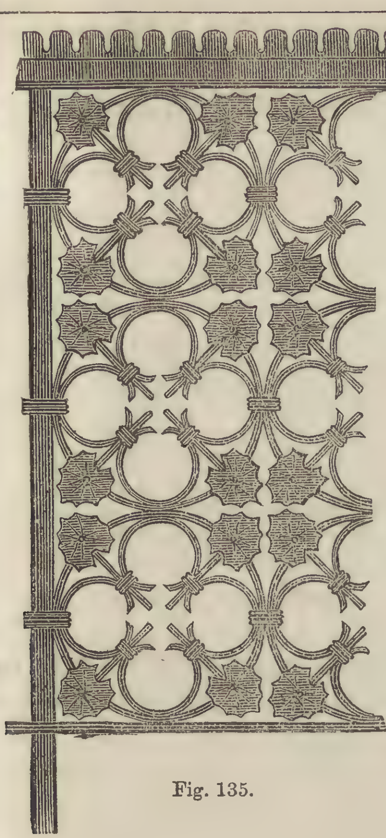


Fig. 135.

excellent works in metal, he will learn more than by much reading. Let him procure, if possible, the illustrated catalogues of such men as Hart of London, Hardman of Birmingham, and Dovey of Manchester, and study the sketches which he will there see, and he will certainly discover the principles of a true art, such as he must seek to apply in a manner concordant with his own original feelings.

Of our illustrations, the example by Skidmore (Fig. 137) furnishes us with an excellent mode of treatment. Iron bands are readily bent into volutes, or curves of various descriptions, and the parts so formed can be united by welding, screws, or bolts. Hardman's gate (Fig. 134) is in every respect excellent; it is quaint, vigorous, and illustrative of a true mode of working metal. The two foliated railings (Figs. 135, 136) are also very meritorious. They are simple in design, and their parts are well fastened together. I advise very strongly that the student carefully consider the illustrations which have accompanied this lesson. The same subject will be continued in the next chapter, in which further examples of ornamental iron work will be given from ancient and modern sources to which I am anxious to call the attention of the student.

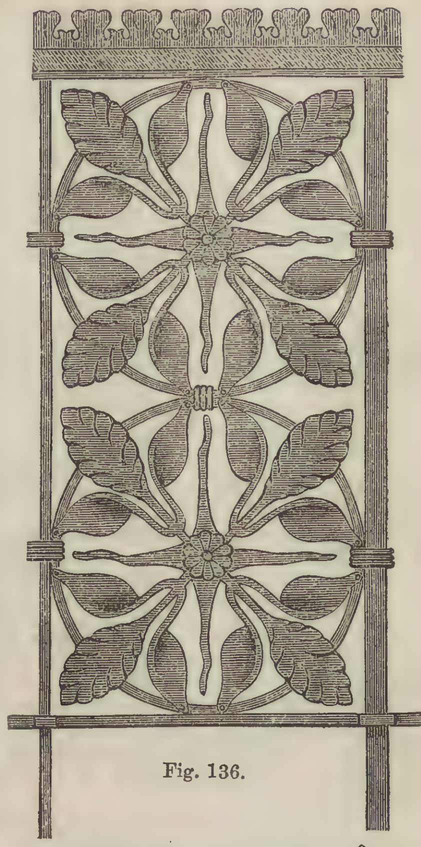


Fig. 136.

Fig. 137.

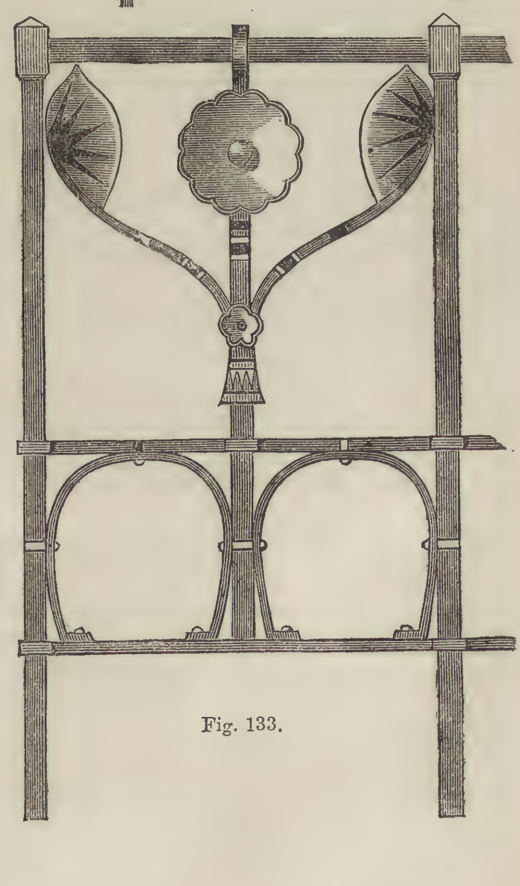


Fig. 133.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VIII.

BY E. WYNDHAM TARN, M.A.

CARPENTRY.

THE work of the carpenter is the framing of timber in roofs, floors, and partitions, the construction and erection of centerings for brick or stone arches, fixing bracketing for cornices of rooms, battening the walls for plastering and the roof for slating, laying rough boarding, framing and fixing solid sash and door frames, erecting wood fencing to gardens, and all woodwork of a heavy or rough description.

In measuring timbers used in building, care must be taken to keep them separate, according to the position and manner in which they are fixed; but all are measured by the cubic foot, the length and scantling, that is breadth and thickness, being entered under each other in the dimension book, and described according to the labour upon them. Timber which is laid in walls with little or no labour upon it beyond cutting into lengths and fixing is taken under one head as bond, plates, sleepers, templates, lintels, etc.; deduct half the length of the bond timber which is cut out of openings. In single-joisted floors the timbers are taken as "framed in joists;" in double-joisted floors, where the bridging and ceiling joists are notched on binders, as shown in Fig. 136 of Lesson XIV. on "Building Construction," take the joists as in single floors and the binders separately as "framed in binders," and if the binders are themselves framed into other timbers called girders, as in Fig. 117 of Lesson XIII. on "Building Construction," the girders are put into the same category as the binders. Trimmers and trimming joists round openings in single-joisted floors are classified with binders and girders. Bressummers to carry walls over openings, or girders sawn down, reversed, and bolted or trussed, are placed by themselves as "framed girders, etc.," the iron trusses and bolts being taken by weight.

The timbers of trussed roofs are measured their full length, allowing for tenons, scarfings, and other joints, as described in Lessons XII. and XIII. on "Building Construction." When the scarfing of long tie-beams is made as shown on Figs. 95, 96, etc., the length of the scarf must be measured twice, in order to get at the timber used, keys and wedges being numbered, and the iron bolts taken by weight. The timbers are described as "cube framed in trusses;" the common rafters, purlins, gutter plates, and such timbers as do not form part of the trusses are taken together and kept separate from the trusses. If any of the timbers are planed to a smooth face for staining or painting, the labour is taken separately, and measured by the foot superficial.

When the ridge, hip, or valley pieces are less than three inches thick they are measured by the foot superficial, and all cuttings by the foot run. Tilting fillets and feather-edged eaves-boarding for raising the slates at the eaves, are taken by the foot run; also take the run of hip and ridge rolls.

The boarding or battening of roofs for slates or any other covering, is taken by the square of 100 superficial feet, stating the thickness, width, and distance apart of battens. Valley and gutter-boards are taken by the foot superficial.

In measuring the king-post of a trussed roof, as shown at Fig. 151 of Lesson XV. on "Building Construction," one only of the pieces cut out to form a shoulder is to be deducted from the cube of the timber; and in queen-posts deduct only half of one of the pieces cut out. Blocks to support the purlins on the rafters are numbered; also number all wood-bricks inserted into a wall for fixing the joiner's work. Drips and cesspools in gutters are to be numbered.

Measure herring-bone strutting placed between the joists of a floor, as shown in Fig. 133 of Lesson XIV. on "Building Construction," by the foot run, taken across the joists. Sound boarding placed on fillets half way down the joists, as shown at Fig. 134, is taken by the square of 100 superficial feet, measured over the whole surface of the floor, without any deductions for thickness of joists. Sometimes, however, the exact measurement is taken, deducting the joists, and must then be described as "nett."

In measuring quarter partitions, as shown by Fig. 181 in Lesson XVIII. of "Building Construction," the timbers forming the trusses, as head, sill, and braces, are taken as "cube in trusses." The quarters which fill in the spaces between the trusses, and to which the plasterer attaches his laths, are cubed separately, and may be added to the common rafters or joists.

Bracketing for plaster cornices of ceilings and cradling for shop fronts are measured by the foot superficial, taking the length by the girth. Circular work may be taken double measure, and all angular brackets numbered in addition to the superficial measurement.

When walls are battened out to receive the plaster the battening is measured by the square of 100 feet, deducting all openings, stating the thickness, width, and distance apart of the battens.

Centerings to vaults and other large arches are measured by the square of 100 feet, taken on the soffit of the arch. Centerings to smaller arches are measured by the foot superficial, and turning pieces by the foot run.

Where timbers are cut in the form of a circle, take the cube of the original timber required to allow for the sweep, and measure the labour by the foot run. In the case of arched heads to solid door or window frames, take the run of the curve and describe as framed, rebated, and beaded circular heads, glued up in thicknesses. The straight parts of solid door-cases and window-frames are measured by the foot cube and described, oak sills being taken separately from the fir frames. In measuring square-headed frames the head must be measured six inches longer than the outside width of the frame, and the jambs two inches longer than the height, to allow for stubs into the sill.

Weather boarding and rough boarding is measured by the square of 100 feet.

In measuring wood fences formed of cleft oak pales with arris rails and oak posts, take the length in feet and bring it into rods of 16 feet 6 inches, describing the height. If there is an oak plank at the bottom or capping on the top, measure them separately by the foot run. Field gates, gate posts, etc., are numbered and the size described.

Guard fences, of cleft rails and posts are taken by the rod of 16 feet 6 inches.

Timber which is only used temporarily, as in shoring, needling, strutting, etc., is taken by the foot cube, and entered as "use and waste."

Sawyer. Measure the sawing of large timber by the foot superficial, and bring it into squares of 100 feet. If the scantling of the timber is 6 inches or less, take the sawing by the foot run.

We shall now illustrate the foregoing rules by a series of dimensions of the various materials and labour required in the carpenter's work of a building.

20)	15 9 0 11 0 2½	60 2	C. fir joists.
	45 0 0 4½ 0 3	4 3	Ditto wall plate.
2)	45 0 0 9 0 3	16 11	Ditto bond timber.
2)	1 9 0 9 0 3	0 8	Ddct.
		16 3	
2)	15 9 0 11 0 3	7 3	Ditto trimmers.
20)	15 0 0 5 0 2	20 10	Ditto joists.
4)	24 0 0 4 0 3	8 0	Ditto sleepers.

20)	25 0 0 3 0 2	20 10	Ditto ceiling joists.
4)	16 0 1 2 0 7	43 7	Ditto binders.
3)	16 0 1 1 1 1	56 4	C. fir girders, sawn down, reversed, and bolted together.

No. 30 wrought iron bolts, $\frac{1}{2}$ in. diameter, 15 in. long, with heads and screw nuts.

3)	16 6 1 1 0 7	31 3	C. fir tie beam.
3)	5 6 0 7 0 9	7 3	Ditto king-post.
	4 0 0 7 0 3	0 7	Ddct. shoulder.
		6 8	
2)	25 6 0 7 0 7	17 4	Ditto purlins.
6)	4 6 0 7 0 4	5 3	Ditto struts.
20)	12 0 0 4 0 3	20 0	Ditto common rafters.
2)	25 0 0 4 0 3	4 2	Ditto pole plate.
	25 6 0 11	23 5	$1\frac{1}{2}$ in. ridge piece.
2)	24 0 1 3	60 0	1 in. gutter boards and bearers.

No. 4 drips, 2 cesspools.

2)	24 6 12 0	588 0	$\frac{3}{4}$ in. battening, $3\frac{1}{2}$ in. wide, laid for countess slating.
2)	24 6	49 0	Tilting fillet.
	24 6	24 6	2 in. ridge roll.

No. 6 blocks to purlins.
,, 24 wood bricks.

	24 0	24 0	Herring-bone strutting.
	24 0 15 0	360 0	1 in. sound boarding on two fillets.
	24 0 11 0	264 0	$\frac{3}{4}$ in. battening to walls, plugged, with battens $2\frac{1}{4}$ wide, 10 in. apart.
	6 6 3 6	22 9	Ddct. opening.
		241 3	

3)	15 6 0 6 0 6	11 8	C. head and sill to trussed partition.
	16 6 0 5 0 6	3 5	Add braces.
	23 0 0 5 0 6	4 10	Add ditto.
2)	8 0 0 6 0 6	4 0	Add door posts.
		23 11	
10)	11 0 0 6 0 3	13 9	Ditto quarters.
7)	3 0 0 6 0 3	2 8	Add.
		16 5	

No. 2, 1 in. wrought-iron bolt, 12 ft. long, with nuts, plates, and screws.
,, 2, $\frac{1}{2}$ in. bolts, 12 in. long, with nuts and screws.

	90 0 1 6	135 0	Bracketing to cornice.

No. 4 angle brackets.

2)	6 6 5 0	65 0	Centering to vaults.
4)	5 9 0 9	17 3	Ditto to arches.
6)	3 6 1 6	31 6	Ditto trimmers.
		113 9	
4)	3 6	14 0	Turning pieces, $4\frac{1}{2}$ wide.
2)	17 6 0 4 0 3	2 11	C. fir, wrought, rebated, and beaded (or "proper") door-case.
2)	10 0 0 4 0 3	1 8	Ditto, ditto, window frame.
		4 7	
2)	6 3	12 6	Circular heads to window-frame, rebated, beaded, and glued up in thicknesses, 5″ × 3″.
2)	4 6 0 4 0 3	0 9	C. oak, wrought and weathered sill.
4)	12 6 8 0	400 0	1 in. weather boarding.
	13 0 3 0	39 0	Ddct.
		361 0	
2)	110 0	220 0	5 feet cleft oak pales, with 2 arris rails and oak posts, 9 ft. apart.

45 0	45 0	Add.
	265 0	
265 0	265 0	1 in. oak plank, 12 in. wide to ditto.
265 0	265 0	Oak capping to ditto.

No. 2, oak gate posts, 12″ × 12″, 5 feet high.
„ 1, 5-bar field gate, 9 ft. wide with sawn rails.

44 0 1 2 0 7	29 11	C. fir, use and waste for shoring.
20 0 0 11 0 3	4 7	Add.
6 0 0 6 0 6	1 6	Add.
	36 0	
21 6	21 6	Arris gutter, 4 in. deep, ¾″ deal.
10 3	10 3	Water trunk, 4½ in. square, ¾″ deal.

No. 1 shoe for trunk. 2 joints for ditto. 1 hopper head.

2)	5 6 2 6	27 6	1 in. deal, feather edge louvre boarding.
3)	16 6 3 4	165 0	Planing fir, tie beams.
3)	5 6 2 8	44 0	Add king posts.
2)	25 6 2 4	119 0	Add purlins.
6)	4 6 1 10	49 6	Add struts.
3)	16 0 2 2	104 0	Planing underside of girders.
		481 6	

SAWYER.

4)	42 0 1 2	196 0	Sawing fir.
10)	24 0	240 0	Ditto 6 in. oak rails.

ABSTRACT.

Cube.		Superficial.		Run.		Numbers.	Smith.
Fir in bond, etc. ft. 4 3 16 3 8 0 4 2 32 8 Fir in joists, etc. ft. 60 2 20 10 20 10 20 0 16 5 138 3 Fir framed in trusses. ft. 7 3 43 7 31 3 6 8 17 4 5 3 23 11 135 3 Fir framed in girders, sawn down, and reversed. 56 4	Fir proper door-case and window frame. ft. 4 7 Fir, use and waste in shoring. ft. 36 0 Oak sill, weathered. ft. 0 9	1½ in. ridge piece. ft. 23 5 1 in. gutter board and bearers. ft. 60 0 Planing fir. ft. 481 6 ¾ in. battens, 3½ wide, laid for countess slates. ft. 100)588 0 5 sq. 88 ft. 1 in. sound boarding, on two fillets. ft. 100)360 0 3 sq. 60 ft. ¾ in. battening to wall, plugged, 2¼″ wide, 10 in. apart. ft. 100)241 3 2 sq. 41 ft.	Bracketing to cornice. ft. 135 0 1 in. deal louvre boarding, feather-edged. ft. 27 6 1 in. deal weather boarding. ft. 100)361 0 3 sq. 61 ft. Centering to arches. ft. 113 9	5 ft. cleft oak pales, 2 arris rails, oak posts 9 ft. apart. ft. 16·6)265 0 16 rods. 1 in. oak plank to fence, 12 in. wide. ft. 265 0 Oak capping to fence. ft. 265 0 Tilting fillet. ft. 49 0 2 in. ridge roll. ft. 24 6 Herring-bone strutting. ft. 24 0 Turning pieces, 4½″ wide. ft. 14 0	Circular head to window-frame, glued in thicknesses, 5″ × 3″. ft. 12 6 Arris gutter, 4″ deep, ¾ in. deal. ft. 21 6 Water trunk, 4½″ square, ¾ in. deal. ft. 10 3	Shoe to water trunk. 1 Joints to ditto. 2 Hopperhead ditto. 1 Blocks to purlins. 6 Wood-bricks. 24 Angle pieces to bracket of cornice, 18″ girt. 4 Drips to gutter. 4 Cesspools ditto. 2 Oak posts, 12″ × 12″, 5 ft. high. 2 Five-bar field gate, 9 ft. wide, with sawn rails. 1	½ in. w. iron bolts, 15″ long, with heads, nuts, and screws. 30 Ditto, ditto, 12″ long. 2 1 in. w. iron bolt, 12 ft. long, nuts, plate, and screws. 2 SAWYER. Superf. Sawing fir. ft. 100)196 0 1 sq. 96 ft. Run. Sawing 6 in. oak rails. ft. 240 0

In applying the foregoing rules to the measurement of carpenter's work, all the materials and labour are supposed to be supplied by the carpenter or the contractor who employs him. If, however, the timbers and other materials are delivered to the building by the person for whom it is being erected, and at his expense, then the carpenter's work can be measured in the manner before described, and entered as "Labour and fixing," or as "Labour and nails" which includes glue, attendance on sawyers, etc. But it is more usual in this case to take the roofing, flooring, partitions, centering, rough boarding, weather boarding, etc., all by the square of 100 superficial feet, describing the character of the work to be done.

Timber is purchased by the "load" of 50 cubic feet. Planks, deals, and battens, 2½″ and 3″ thick, by the hundred of 120;

planks being 11 inches wide, deals 9 inches, battens from 3 to 7 inches wide.

To find the cubical contents of a "baulk" of timber in its rough and uncut state, take one-fourth of the girth round the *middle*, square it, and multiply by the length; the baulk being slightly tapered, or smaller at one end than the other.

When 3-inch deals or battens are cut into two equal thicknesses, they are called "one-cut;" if into three equal thicknesses, they are termed "two-cut;" if into four equal thicknesses, "three-cut;" and so on, according to the number of saw cuts required. One and a half inch deal is generally understood to be the same as "one-cut," being got out of three-inch deal by one saw-cut down the middle; 1-inch deal as "two-cut;" ¾-inch as "three-cut," and so forth.

FARMING AND FARMING ECONOMY.—XI.

By Professor Wrightson, Royal Agricultural College, Cirencester.

ARABLE VERSUS PASTURE LAND.

The question of arable versus pasture land is interesting to the economist, the philanthropist, and the agriculturist. This many-sidedness constitutes its chief difficulty, and is the cause of much difference of opinion. Mr. Mechi well represents a class of thinkers who view this subject from a somewhat speculative standpoint. In a lecture before the Farmers' Club, upon the undeveloped powers of British agriculture (Nov., 1868), he thus speaks of what appears to him to be one of the greatest causes of agricultural non-development. Grass land or permanent pasture "is the grand field to which we must look for development and progress. One half of the United Kingdom is in permanent pasture. The last Board of Trade returns give 22,156,541 acres in 1867 as against 21,174,787 acres in 1866, showing an increase of 981,754 acres in grass land.* These returns are exclusive of heath or mountain lands." Again, "We have heard too much lately about laying down land to grass and depending upon foreign countries for corn. Judging from the latest statistics, that opinion appears to have been acted upon. I protest against this mistaken practice, as most injurious to the country." The evils of this system are summed up by Mr. Mechi as "starving the people and depriving them of employment." Figures are also quoted to show the immensely greater produce derivable from arable than from pasture land. "Our 11,500,000 acres in corn crops produce on an average an annual sum of about £83,000,000, besides straw. What do our 22,000,000 acres of permanent pasture produce? According to my rough or approximate estimate, only about £50,000,000, or about 43s. per acre, while our 11,500,000 acres of corn, produce £8 per acre, besides about £2 worth of straw."

Neither is the opposite policy of laying down land to grass without supporters. It is confidently argued that Great Britain is not a corn-growing, but a grazing country; that the climate is favourable to grass and unfavourable to cereals; that in live stock she is pre-eminent, while in the corn trade she competes at a decided disadvantage with foreign countries. Therefore—for this is the corollary of the proposition—let us lay our land down to grass, grow beef and mutton, and purchase corn in the markets of the world at large! Both these views are alike unpractical, because they never will influence the actions of those most directly interested in the question at issue. The true method of approaching this question was indicated by Mr. Clare Sewell Read, M.P., at the February meeting of the Farmers' Club, 1870. He said, "They were constantly lectured on their duty to the public. They were constantly told that in these days it was the duty of the farmer to grow more; but he believed that that was a secondary duty, and that the main duty of a farmer was, if possible, to make his farm pay. He, for one, knew perfectly well that pasture land might be broken up and might produce more meat, and yet what was done might be an utterly losing game." Mr. Read's tersely-expressed views may fairly be looked upon as representing the opinion of the majority of agriculturists. It is a thoroughly practical conclusion, based upon the solidity of existing institutions, but cannot be considered as an answer to speculative arguments founded upon abstract principles rather than upon present circumstances. Rightly or wrongly, we have forsaken the coercive methods of regulating industry adopted by our forefathers. We no longer artificially check the flow of precious metals from our shores, or frame laws to protect certain interests. We can hardly imagine the revival of the laws limiting the number of sheep possessed by one man to 2,000 (Henry VIII., 13 of 25), forbidding any man to occupy more than two farms; or land to be laid down in pasture (Froude's "History of England," vol. i., page 34). Such acts were passed in accordance with views similar to those held by Mr. Mechi, and, if based upon correct principles, they ought to be, if not repealed, enforced. Inclining, as we do, to the general principle of non-intervention, as most likely to encourage the art of agriculture, we are bound to agree with Mr. Read that the relative net profit, and not the relative productiveness of the two classes of land, should be the crucial test applied. We believe, also, that these views would be supported by economists; for if pasture land were more profitable than arable land, then would the labour expended in converting and maintaining it as arable land be, to some extent, unproductive, and would be better diverted into other channels. The same argument might be used to dispose of the supposed advantage accruing from the increased capital required in the case of such broken-up lands; for if capital is not profitably invested it will inevitably be withdrawn and placed in some more remunerative enterprise.

Those who urge the wisdom of ploughing up grass lands do so on the following grounds:—First, that the amount of human food would be increased—according to Mr. Mechi, quadrupled; second, that an immense field for labour would be opened; third, that a safe investment would be offered for native capital. To which splendid reasons we have only one answer to make—That so long as an individual finds his grass fields more profitable than his arable fields, he probably will keep them as they are.

But the question of arable versus pasture land cannot be summarily settled. There are so many kinds of land, that it is impossible to lay down a law applicable alike to all. It becomes necessary to classify our pastures, and in so doing we may find it advisable to allow some to remain as grass, while others would be more profitable as arable land. All pastures may be arranged under one or other of the following heads:—

1st. The best bullock grazing grounds, such as abound in Lincolnshire, the Midlands, Somersetshire, and more or less in every county.
2nd. Clay land pastures of fair or good quality.
3rd. Poor clay land pastures.
4th. Light land pastures of fair or good quality.
5th. Poor light land pastures.
6th. High-lying mountain land, precipitous in character and ungenial in climate.
7th. Waste lands, such as downs and heaths.

THE BEST BULLOCK LAND.

All agriculturists agree that lands of this class are better left in grass. Testimony to this effect might be adduced to almost any extent, but we forbear, presuming that such opinions are based upon sufficient reasons; and we prefer laying before our readers some of the most weighty arguments which support this conviction. Good grass lands command a higher rent, and a greater profit to the tenant, than any arable land. Secondly, it requires many years to bring them into the condition of old sward. Easy as it is to break up a pasture, or cut down a tree, it is about equally difficult to replace the one as the other. This is understood by agriculturists, who well know that the peculiar condition of good old turf is only arrived at after land has been laid down for many years. Thirdly, such land is a safer property; its produce has risen in value, and may rise higher; it is less troublesome, and less subject to casualties.

According to Mr. Morton ("Farmer's Calendar," page 524), one acre of first-rate grazing land in Lincolnshire will, under the best circumstances, feed an ox and a sheep from New May Day

* The returns for 1870 state the area under corn in the United Kingdom as 11,755,053 acres, or 322,000 acres more than in 1867. The extent in permanent pasture was in the same year 22,085,295, which was distributed as follows:—

Great Britain	12,072,856 ac.,	or 40 per cent. under permanent pasture.
Ireland . .	9,990,968	,, 64 ,, ,, ,, ,,
The Islands .	21,471	,, 19 ,, ,, ,, ,,
	22,085,295	

This therefore indicates a decrease of permanent pasture since 1867.

to Old Michaelmas; the former will gain 20 stone, or 290 lbs., and the latter 10 lbs. per quarter, or 40 lbs., in the time. Taking 7d. per lb. as a very moderate price for this produce, we have 320 lbs. at 7d., or £9 6s. 8d., as representing its value. Or if we assume, with Mr. Morton, that the average produce of such land is 12 tons per acre of grass, which will be equivalent to 3 tons of hay, this represents, at £3 per ton, £9 per acre.

Now it requires very good land, very good farming, and very propitious seasons, to produce £10 per acre average upon cultivated fields. This is clearly shown by the following statement of the crops necessary to produce such a sum:—

First year.	20 tons of swedes, realising, when fed off, 5s. per ton	£5	0	0
Second year.	60 bushels of barley, at 4s. 6d. per bushel	13	10	0
Third year.	3 tons of clover hay, at £3 (consuming value)	9	0	0
Fourth year.	45 bushels of wheat, at 6s. . . .	13	10	0
		4)41	0	0
		£10	5	0

To set against this income would be a manual labour bill of £2 (for heavy crops require extra labour), a horse labour account of £1, and a seed bill of 10s. per acre. Farmers who grow such crops generally have heavy purchased manure and food accounts; but since we have assumed the land to be of rich quality, we shall place these at £1 per acre. Without taking into account the other numerous charges connected with arable land—such as blacksmiths', joiners', saddlers', and other tradesmen's bills, new implements, etc., we are compelled to reduce the gross profits, to be divided between landlord and tenant, from £10 to £5 10s. per acre.

We have presented two cases of arable and pasture land, both under very favourable circumstances; but in doing so we have not forgotten the chances of season and disease. These items may, however, be considered as cancelling each other, and the balance will accordingly appear on the side of the grass land.

CLAY LAND PASTURES,

Whether of good or bad quality, ought not to be ploughed up. These lands are intractable under tillage; they are essentially adapted for growing corn rather than root and forage crops, and for these reasons are less likely to be profitable under cultivation than lighter soils. Let those who insist upon breaking up such pastures reflect upon the advantage of employing the necessary capital in improving the same land in its present condition. Let it be drained, limed, annually dressed with liberal applications of superphosphates and guanos, for at least four seasons, plentifully stocked with sheep and cattle receiving cake and corn, the land being judiciously managed in every other respect, and we venture to predict that it will repay the enterprising landlord or tenant with a richer harvest than even waving wheat fields could afford.

LIGHT LAND PASTURES

Offer a more promising field for those who recommend tillage as preferable to grass. Such land, when broken up, yields plentiful supplies of root and forage crops, and is well adapted also for barley and wheat. It is land which will grow anything, and is worked at comparatively small cost. On the other hand, it is not so well adapted for growing grass as clay soils, being susceptible of injury from drought, and not unlikely to "burn" in the summer months. If such lands do not produce sufficient grass, the question becomes easier of solution, and we would unhesitatingly recommend the plough.

HIGH-LYING MOUNTAIN LAND

Will probably remain in grass, although it may be improved by a short course of tillage. Thus, on the Lammermuir Hills it is a common practice to break up the inferior pastures, and after taking a crop of oats and turnips, to lay them down with a suitable mixture of grass seeds.

WASTE LANDS, SUCH AS DOWNS AND HEATHS,

Offer the most promising prospect for converting grass into arable land. It is evident that the heath farmers of Lincolnshire, the wold farmers of the same county and of Yorkshire, and the occupiers of down lands in many of the southern and western counties, have reaped advantage from the breaking up of such lands. Take, for example, the case of the Lincolnshire heath, a district described in the middle of last century as covered with heath, fern, and gorse, the only fences being the furze-capped walls of sand that enclosed the rabbit warrens.

In 1789 Arthur Young describes the enclosures as having been made within the last twenty years. The effect of arable culture here has been marvellous. Rents have risen from 1s., 2s., and 3s. per acre to 30s. tithe free. The land is naturally easily worked, and is adapted for turnips and barley husbandry, as well as for sheep. "Every part of it," writes Mr. John A. Clarke, "is under culture, abounding with spacious, well-constructed farm buildings, strong well-fed working horses, and immense folds of sheep. The barren sheep-walk and warren have been clothed in fruitfulness, and their richness preserved by unremitting weeding and unstinted manuring." Such examples of the advantage of converting what may be called pasture into arable land abound; but they may be more correctly spoken of as successful instances of reclaiming waste lands.

We have now considered all the classes into which the pasture lands (using the word in its widest sense) may be divided. We may conclude that espousing either side of the question of arable versus pasture land is likely to lead into error, and that the true method of approaching the subject rests in appreciating thoroughly two important facts—first, that under our present political and social economy it is merely a question of profit and loss; and, secondly, that there are many classes of pasture land, and that one rule cannot be made applicable to all.

SHIP-BUILDING.—IX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF IRON SHIPS (*continued*).

In this paper we propose to give some account of the system of framing adopted in the iron-built armoured vessels of the Royal Navy. This system—usually known as the "bracket frame" system—is an outgrowth of the longitudinal system, of which Mr. Scott Russell is the author; but it differs from the earlier plan in many very important particulars, and is, by general consent, acknowledged to be better adapted than any other to the special requirements of iron-clad war-ships. Since the first iron-clad, the *Warrior*, was built, considerable changes have been made in the methods of constructing such vessels, and the bracket-frame system itself has been since introduced; but with these changes we cannot concern ourselves here, and shall restrict attention to arrangements such as would now be considered good.

Mr. Reed, the late Chief Constructor of the Royal Navy, to whom the introduction of the bracket-frame system is due, thus briefly sums up its characteristics:—"The objects of the invention and introduction of this system were to save weight, to simplify workmanship, and to add both to the strength and safety of the ship. The characteristic features of the system are the adoption of an inner bottom, and of short angle-irons connected by bracket-plates, in place of staple and other forged angle-iron work. A great increase of longitudinal strength is gained by the use of much deeper longitudinal frames than those of the *Warrior* and other of the earlier iron-clads. Another important feature resulting from the employment of deep longitudinals, is that the space between the two bottoms is roomy, and easy of access for cleaning and painting—operations which are essential to the preservation of an iron structure. Facilities are also offered by these arrangements for letting in water between the bottoms to serve as ballast, the space being so divided into watertight compartments as to enable the officer to regulate the trim of the vessel by filling the fore or the aft spaces. Provision is, of course, made to pump out any compartment when required."*

The sectional view of a portion of the framing of a ship so built, in Fig. 23, will enable the principal features of the system to be understood more clearly. The main frames will be seen to consist of strong continuous longitudinal girders, L L, placed at the centre-lines of the alternate strakes of bottom plating. The central keel, or keelson, K, stands upon a flat keel formed of two thicknesses of plating. There is an internal skin upon the inside of the longitudinals, and this, being made watertight,

* "Ship-building in Iron and Steel," page 110.

forms the inner boundary of the double bottom. It is also customary to make the centre keelson, or vertical keel, watertight, as well as the fourth or fifth longitudinal frame out from the keel, thus subdividing the space in the double bottom.

The provision of longitudinal strength is, therefore, similar in principle to that previously described, and all that was previously said respecting the necessity for carefully shifting and fastening the bolts of the longitudinals applies here also. In the arrangements of the transverse framing, an entirely new method is adopted. The transverse frames are placed about 4 feet apart, instead of being 12 or 14 feet apart, as are the partial bulkheads in Mr. Scott Russell's system. The frame angle-irons, F F, to which the outside plating is riveted, are fitted in short lengths between the longitudinals; but the reversed frames, C C, to which the inner skin is fastened, are continuous, notches being cut in the inner edges of the vertical keel and the longitudinals, in order to allow the reversed frames to pass through unbroken. In consequence, the angle-irons on the inner edges of the longitudinals have to be worked in short lengths between the continuous transverse angle-irons; while the angle-irons on the outer edges of the longitudinals are continuous, like the plates to which they are attached. This plan leaves a large reserve of longitudinal strength, and at the same time provides a continuous transverse tie from side to side, such as does not exist in a vessel built on the ordinary longitudinal system. Of course, it is not meant that even in the latter case the indirect transverse connection at the partial bulkheads is not a strong one; but on the whole, a direct connection, such as is provided at frequent intervals in the iron-clads, seems preferable.

To connect the frame and reversed frame angle-irons to each other as well as to the longitudinals, "bracket" plates, B B (Fig. 23), with short angle-irons on their ends are employed, and they have given a name to the system of construction. Their usefulness will be obvious, and so will be the simplicity of workmanship, combined with strength of connection, that results from their employment. By means of them a very small weight of material is made to supply ample transverse strength to the lower part of the hull, and at the same time to furnish that support to the outside plating which is wanting in vessels with widely-spaced partial bulkheads. The primary character of the longitudinal framing is left untouched; but while the transverse framing is subordinated thereto, it is made strong as well as light. Throughout the length of the double bottom—which would be about two-thirds of the total length of the ship—the bracket-plate arrangement is conformed to for four out of every five or six of the transverse frames. At intervals of about 20 or 24 feet, however, solid plate frames are substituted for brackets, and are made watertight, thus further subdividing the space between the two skins, and forming compartments of moderate size. This subdivision, besides possessing the advantages alluded to above, adds considerably to the safety of the ship in case the outer plating is broken, because the water which might enter under such circumstances would only have access to a very limited space.

Before and abaft the double bottom it is not customary to use bracket-frames, but to fit "lightened plate-frames" instead. These are formed very much in the same fashion as the partial bulkheads in Mr. Scott Russell's ships, only they are not more than 4 feet apart, and are lightened considerably by cutting large pieces out of the central portions of the plates. This principle of lightening all parts of the framing to the greatest possible extent consistent with a retention of a proper amount of strength is carried out most thoroughly in the iron-clads, and the aggregate saving in the weight of hull thus effected is very considerable. As another example of this practice, we may refer to the longitudinal frames. These are formed of very deep plates, with angle-irons on the edges; and at the stations of the transverse frames, which occur at intervals of 4 feet, these plates are necessarily weakened by the lines of holes punched to receive the rivets in the connecting angle-irons, as well as by the scores or notches cut out to permit the passage of the continuous transverse frames. To leave the full strength of the plates untouched between these unavoidably weakened sections would obviously be unwise, because there would then be a great want of uniformity in the strength of the longitudinal frames, and that would be contrary to one of the fundamental principles of construction. What is actually done is to cut large holes in the parts of the longitudinals lying between the stations of the transverse frames, the sizes of the holes being so determined as to leave the plate at least as strong in wake of them as it is at the adjacent weakened sections; and so a saving of weight is effected without any loss of strength. In arranging the fastenings of the butts of these longitudinals, it is also the practice to aim at a strength as nearly as may be equal to that of the unavoidably weakened sections, and greater uniformity of strength is thus ensured.

Most of the longitudinals are continued right forward to the stem, and are strongly connected with it, thus strengthening the bow most efficiently for use in "ramming," a method of attack that seems likely to be much used in future naval engagements. Towards the stern special methods of framing are required, in order to provide the necessary strength to resist the strains caused by the screw propellers, which are by no means of small amount in these large swift vessels. On this account it is customary in ships with single screws to end all except two or three of the longitudinal frames at a bulkhead 16 or 20 feet before the stern-post; but in twin-screw ships the longitudinals are sometimes run right aft to the stern-post. The transverse framing at the after end is formed by lightened plates, with stiffening angle-irons on the edges, and it has a very important part to play. It is satisfactory to know, however, that in these powerful steam-ships, with engines developing from 6,000 to 8,000 horse-power, no signs of weakness have been found at the sterns, and the fact constitutes not the least important evidence of the superiority of iron to wood.

In constructing armoured ships special requirements have to be met, and the builder has to consider how best to combine lightness with strength and safety, in order that he may be able to carry thicker armour on the sides and heavier guns in the batteries. He has also to devise arrangements that will turn the armoured portion of the vessel into a strong target, and at the same time to ensure efficient connection between that part of the structure and the unarmoured under-water part of the hull. The system of bracket-framing is, of course, only used for the unarmoured part, and it would end at the height where the armoured side begins, say 5 or 6 feet below the line at which the ship is intended to float when fully equipped. Above that height the main framing consists of strong transverse frames spaced about 2 feet apart; and the governing idea of the structural arrangements is to make the vessel's side strong against the impact of shot and shell. Only the leading features of these arrangements can be described, and to illustrate them Figs. 24 and 25 have been drawn. In both these figures it will be observed that the armour-plating ends upon a longitudinal shelf, or recess-plate, marked S; this shelf is really the uppermost longitudinal frame of the set to which L L (Fig. 23) belong. Behind the armour come the planks of wood forming the "backing," and upon the inner side of this comes the "skin-plating," worked in two thicknesses. The frames, F F, within the skin-plating, are those just aluded to as having a spacing of 2 feet only. This strong combination is further strengthened by horizontal frames or girders, G G, worked outside the skin-plating at intervals of about 2 feet, and crossing the inside frames at right angles. As a final result a very strong target is formed, which, when tried at Shoeburyness, proved to be capable of resisting most efficiently the great and sudden shocks caused by the blows of projectiles.

To efficiently connect the parts lying above and below the armour-shelf of such a ship is obviously no easy matter, but the difficulty is well met by either of the plans in Figs. 24 and 25. For example, in Fig 24 the alternate frames, F, are continued down, and directly connected with the continuous transverse frames, C C (Fig. 23), thus completing the transverse tie from gunwale to gunwale at intervals of 4 feet. In that case, however, the inner skin is not worked directly upon the frames up to the height of the armour-shelf, but its upper part is placed vertically at some distance within the frames, and formed into what is termed a "wing-bulkhead," well stiffened by angle-irons. The upper part of such a bulkhead is shown in Fig. 24, and is marked B; its lower edge would meet the inside of the frames at a longitudinal, which would be made water-tight, thus shutting off the wing-spaces from the double bottom proper. Against dangers resulting from penetration of the thin outer plating immediately below the armour by shot, by torpedoes, or by ramming, the provision of these wings is obviously advantageous,

and as transverse watertight partitions are fitted in the wings at frequent intervals, such penetration would only admit water to limited spaces, leaving the vessel but little the worse so long as the wing-bulkheads were not broken through. As a means of giving longitudinal strength to the structure, also, such bulkheads are not to be despised.

The arrangement in Fig. 25 differs from that in Fig. 24, in that there is no wing-bulkhead, the inner skin being worked directly upon the frames quite up to the height of the armour-shelf, which is made up of a very broad longitudinal, forming a watertight top to the double bottom. The frame, F, behind the armour, is not continued down (as in Fig. 24) to meet the continuous transverse frames, but is ended upon the armour-shelf, and the double-angle irons on the outer edge are turned inwards so as to be riveted to the shelf-plate. A very strong indirect transverse connection is, however, formed at intervals of four feet by means of the deep plate-frames fitted beneath the shelf, and the angle-irons on their edges. Instead of having the deck-beams formed with knees, as in Fig. 24, a simple plate, B, is used to connect them with the frames, F, and with the shelf-plate. All these changes spring from the fact that the double bottom is continued up to the armour-shelf, and wing-bulkheads dispensed with. The alteration has been made after full trial of the first-named plan; and it appears to have an advantage on the whole over the older arrangement, because it leaves the hold space greater than it would be with wing-bulkheads, and yet provides for strength and safety no less efficiently.

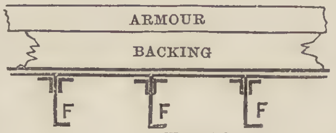


Fig. 26.

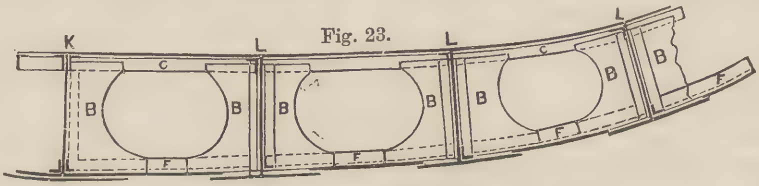


Fig. 23.

The sketches show in sufficient detail how the armour-shelf is connected with the bottom-plating and the skin-plating behind the armour. In order to show more clearly the arrangement and construction of the frames behind the armour, we have given in Fig. 26 a horizontal section of the side of an iron-clad. From this it will be seen that the frames F F are each made up of a deep reversed frame, with double angle-irons riveted to the outer edges. The external girders, G G (Figs. 24 and 25), are usually formed of deep-flanged angle-irons.

This brief description of some of the principal features in the framing of iron-clad ships is all that the space at our disposal permits. Before leaving the subject, however, it may be interesting to illustrate the great advantages that have resulted from using iron instead of wood for the hulls of such vessels. Mr. Reed states that in the *Caledonia*, one of the so-called "converted iron-clads," wood-built, the hull weighs 50 per cent. of the total weight of the ship and all she carries; whereas in the *Audacious*, an iron-clad built on the bracket-frame system, the hull only weighs 45 per cent. of the displacement. The saving in weight of hull obtained by the change in material and system of construction equals therefore 5 per cent. of the entire weight of ship and lading, and in the *Audacious* herself amounted to quite 275 tons. This saving can, of course, be applied in increasing the thickness of the armour, the power of the guns, the force of the engines, the speed of the ship, etc., making her far more formidable than she would otherwise be; at the same time it is accompanied by increased strength, safety, and durability, as compared with the results obtainable with wood ships. On all accounts, therefore, there is reason for congratulation at the change from wood to iron hulls that was made in our Navy simultaneously with the introduction of armour-plating. The French have continued to build mostly in wood; and quite recently statements have been made, apparently on good authority, that many of their earlier armoured ships have become so rotten as not to be worth repair; whereas our iron built ships of equal age are still in good condition, and employed on active service.

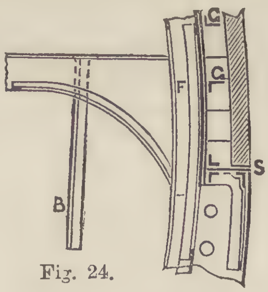


Fig. 24.

FRAMING OF COMPOSITE SHIPS.

In the great features of their framing, ordinary iron and composite ships are very similar. Stripping the iron vessel of her outside plating, with the exception of a strake near the turn of the bilge, and one—named the "sheer-strake"—near the level of the upper deck, and then adding diagonal plate-ties or riders on the outside of the frames, we arrive at the framing of the composite ship. Both have the main frames placed transversely, and supplemented by longitudinal keelsons and stringers; but in the composite ship the skin is of wood, and consequently requires the aid of diagonal ties, for reasons which have been fully explained in previous papers. Flat keel-plates are also commonly fitted in composite ships, and to them the external wood keels, into which the skin is rabbeted, are bolted. These keel-plates are continued up also for some distance on the wood stem and stern-post, which are thus more strongly connected with the wood keel.

The above is the common plan, and will be at once understood by comparison with the account of the framing of iron ships previously given. Many other very singular systems of framing have been used in particular cases, but have not been generally adopted. For instance, several vessels have been built with floors, and middle-line arrangements of keel, keelsons, etc., like those of wood ships, but with frames from the bilges upwards like those of iron ships. Other ships have been constructed with transverse frames formed of T-iron imbedded in wood, and strengthened by very numerous but slight diagonal ties. Others again have been built with no diagonal ties upon the frames; and probably greater variety might be found in the framing of this class than in that of either iron or wood ships, although it numbers comparatively few vessels.

In the "sheathed" ships of the Royal Navy we have examples of a novel principle of construction which may, perhaps, be best referred to in this paper. They are really iron vessels, with the skin-plating rather thinner than would generally be fitted in ships of equal size, and with wood planking or sheathing outside the iron skin. The primary object of this construction has already been stated to be the prevention of fouling by using copper or metal sheathing; and it will be obvious that so far as the framing is concerned, since there is a complete iron skin, the designer has as great a freedom of choice as in an ordinary iron ship. In the particular ships referred to the framing is arranged on a plan differing from either of those described. The main transverse frames are continuous from gunwale to gunwale, and are spaced seven feet apart. Each frame consists of a deep reversed frame, with a single angle-iron on its outer edge. In association with these frames, three or four strong longitudinals are fitted between the upper turn of the bilge and the middle line. Each longitudinal consists of a deep plate, running along inside the main transverse frames, with an angle-iron on its inner edge; and has its lower edge riveted to intercostal plates fitted between the transverse frames. The vertical keel is similarly formed. Intermediate between the main transverse frames, similar frames are fitted extending from the gunwale to the bilge, from which they are completed to the middle line by means of lightened plate frames fitted between the longitudinals. The spacing of the transverse frames is thus reduced to $3\frac{1}{2}$ feet. This system of construction is comparatively simple, and is found to answer remarkably well.

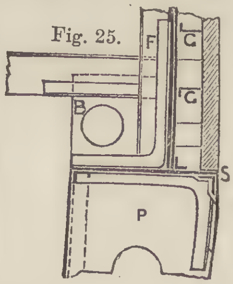


Fig. 25.

TECHNICAL DRAWING.—LXII.

DRAWING FOR BRICKLAYERS.

PRELIMINARY OBSERVATIONS ON BRICKS GENERALLY.

The principles of brickwork having been treated of and illustrated in "Building Construction," the subject will be further worked out in the present lessons, and an opportunity will be given to the students who have obtained general notions of this branch, of increasing their stock of knowledge, and of entering into details of construction and form, thus acquiring the power of delineating works which have been, or are to be, erected, with intelligence and interest.

The work of the bricklayer and that of the carpenter are intimately combined, and these two form the principal part or carcase of the building; their work is *structural*, whilst that of the joiner, the plasterer, the painter, etc., is secondary, or in some cases ornamental.

In the present mode of finishing dwelling-houses in England, everything excepting the outside walls (and even these are often covered with stucco) is cased up by the joiner, plasterer, and painter, in such a way that the whole of the carpentry as connected with the walls is completely hid. In this series of our lessons, therefore, we shall endeavour, by giving sections, etc., to show the manner in which the woodwork is connected with the brickwork, and to give such illustrations of details of construction which could not otherwise be obtained without visiting buildings in course of erection, and watching the progress of the works from beginning to end—a plan which, where possible, is most desirable and important.

Bricks must be considered as artificial stones, and the use of them seems to date from the earliest period of the history of man. We know that the tower and city of Babel were built of bricks, and that the children of Israel were employed in Egypt not only in making, but in building with them, and the numerous bricks found show us the exact size, form, and quality of those used in these remote times.

In speaking of the tower of Babel, we may remark that the remains of this early brick structure, possibly the oldest of the kind that is still in existence, are supposed by Sir R. K. Porter and others to form the Birs Nimrud, a mound of irregular shape about six miles from Hillah, on the western bank of the Euphrates. At the top is a solid pile of brickwork about 38 feet high, and 28 feet broad, rent and partially vitrified by the action of fire, while the summit of the mound is strewn with huge vitrified masses, in which the courses of the bricks can be plainly traced.

The Greeks used chiefly three kinds of bricks—the first sort was called "bricks of *two palms*," the second "of *four palms*," and the third "of *five palms*." Besides these they had also bricks of just half the above dimensions, used for making their work more solid, and for giving an agreeable diversity to its appearance.

The Romans, began to build with bricks towards the decline of the Republic. According to Pliny, those most in use were a foot and a half long, and a foot broad, which agrees with the dimensions of numerous Roman bricks found in England—namely, about 17 inches in length, by 11 inches in breadth.

The stately columns of Venice were built of bricks, which, according to Sir Henry Wotton, were first formed in a circular mould, and cut, prior to their being burned, into four or more sections. Afterwards in laying, they were so closely and accurately joined, that the column had the appearance of being formed of one entire piece.

For the general purposes of building, bricks have certain advantages over stone—not only as being lighter, but also because their porous texture facilitates their union with mortar, and makes them less liable to attract or retain damp and moisture.

In England, the moulds in which bricks are formed are 10 inches in length by 5 inches in breadth. The bricks when burned are rather less than 9 inches long, $4\frac{1}{4}$ inches broad, and $2\frac{1}{4}$ inches thick. The degree of shrinkage, however, is various, according to the purity and temper of the clay, and the intensity of the heat to which it is exposed. In order to avoid double lines to indicate the joints in drawings representing brickwork, the lines are drawn at what would be the middle of the mortar, and the bricks are thus for drawing purposes considered as being 9 inches long, $4\frac{1}{2}$ inches wide, and $2\frac{1}{2}$ inches thick. Paving bricks are 9 inches long, $4\frac{1}{2}$ wide, and $1\frac{3}{4}$ inches thick.

It is usual to compute thickness of walls by the number of bricks or half-bricks extending across them, in which measure-

Fig. 520.—PRESENT APPEARANCE OF THE BIRS NIMRUD—SUPPOSED TO BE THE TOWER OF BABEL.

ment allowance is also made for the mortar used in the vertical joints. Thus, for example, a

1	brick wall	implies	one of	9	inches	thick.
1½	,,	,,	,,	13½	,,	,,
2	,,	,,	,,	18	,,	,,
2½	,,	,,	,,	22½	,,	,,
3	,,	,,	,,	2ft. 3in.		thick.
3½	,,	,,	,,	2ft. 7½in.		,,
4	,,	,,	,,	3ft.		,,

Whilst, however, this method is followed in describing the walls of houses and other civil buildings, the dimensions of the revetments of fortresses or other military structures, and substantial masses of brickwork, are always stated in feet.

In the vicinity of London, bricks are commonly burned in clamps; in many parts of the country, however, it is the custom to burn them in kilns, which not only require less fuel and save time, but also turn out the bricks in a more compact condition.

In building the clamps, the bricks are laid after the manner of arches in the kilns, with a vacancy between every two bricks to admit of the action of the fire; but instead of arching, the space for the fuel is made by making the layers project one over the other from each side until they meet at the top.

The flue is about the width of a brick, carried up straight on both sides about three feet; it is then nearly filled with dry bavins or wood, on which is laid a covering of sea-coal and cinders, or *breeze*. The arch is then overspanned, and layers of breeze are strewed over the clamp as well as between the rows of bricks.

When the clamp is about the width of six feet, another flue is made, in every respect similar to the first. This is repeated at every distance of six feet throughout the whole clamp, which, when completed, is surrounded with old bricks, or some of the driest unbaked ones which have been reserved for the purpose. On the top of all, a thick layer of breeze is laid. The wood is then kindled, which gives fire to the coal, and when all is consumed, which will be in about twenty or thirty days if the weather be tolerable, the bricks are concluded to be sufficiently burned.

If the fire in the clamp burns well, the mouths of the flues are stopped with old bricks plastered over with clay. The outside of the whole clamp is also plastered with clay if the weather be precarious; or if the fire burn too furiously and against any side particularly exposed to rain, screens are laid, made of reeds worked into frames six feet high, and sufficiently wide to be moved about with ease.

A kiln is usually about 13 feet long, about 10 feet 6 inches wide, 12 feet in height, and will burn 20,000 bricks at a time. The walls are about 1 foot 2 inches thick, and incline inwards towards the top, so that the area of the upper part is not more than 114 square feet. The bricks are set on flat arches, having holes left between them resembling lattice-work. The bricks being set in the kiln, and covered with pieces of broken bricks or tiles, some wood is put in and kindled, to dry them gradually; this is continued until the bricks are pretty dry, which is known by the smoke turning from a dark to a transparent colour.

The burning then takes place, and is effected by putting in brushwood, furze, heath-fagots, etc., the mouths of the kiln having been previously stopped with pieces of brick, called *shin-log*, piled one upon another, and closed over with wet brick-earth. This shin-log is carried just high enough to leave room sufficient to thrust in a fagot at a time. The fire is then made up, and continued until the arches assume a whitish appearance, and the flames appear through the top of the kiln, upon which the fire is slackened, and the kiln cools by degrees. This process is continued, alternately heating and slackening, until the bricks are thoroughly burned, which is generally in the space of forty-eight hours.

OF THE VARIETIES OF BRICKS.

The bricks most generally used are *marls* or *malms*, *stocks*, and place bricks; but there is little difference in their manufacture. Marls are prepared and tempered with the greatest care; but the construction of the clamp for burning them is similar to that for other bricks, though more caution is required not to overheat them, and to see that the fire burns equally throughout the clamp or kiln.

The finest malms, called *firsts*, are selected as cutting bricks for arches of doorways, windows, and quoins, for which purpose they are rubbed to their proper dimensions and form.

The next best, termed *seconds*, are used for principal fronts when superior work is required. The cleanly, pale yellow colour of malms, added to their smooth texture and durability, give them a pre-eminence over other sorts of bricks. The kind of bricks most used in each county depends, however, principally on the clay found in the immediate locality; thus the white Suffolk may be called a London brick, whilst the red clay in Cheshire yields the red bricks used to so great an extent in that district.

Graystocks are somewhat like the seconds, but of an inferior quality. These may be termed the standard bricks, and although not equal to malms, should possess two qualities—they should be sound in body and pale in colour; in fact, the nearer they approach stone in this respect the better.

Place bricks, sometimes called *peckings*, *sandal*, or *samel* bricks, are such as, from being outside a kiln or clamp, have not been thoroughly burned, and are consequently soft, of a more uneven texture, and of a red colour. There are also *burrs* or *clinker* bricks, such as, from being too violently acted upon by fire, have vitrified in the kiln, and sometimes several are found run together.

Red stocks are made in different parts of the country, and owe their colour to the nature of the clay of which they are formed, which is always tolerably pure. The best sort are used as cutting bricks, and are called *red rubbers*. In old buildings they are frequently to be seen, ground to a fine smooth surface, and set in putty instead of mortar, as ornaments over arches, windows, doorways, etc. Though many very beautiful specimens of red brickwork are to be met with, yet (says Mr. Peter Nicholson) "these bricks can seldom be judiciously used for the fronts of buildings, the colour is much too heavy, and in summer conveys an unpleasant idea of heat to the mind, to which may be added that, as in the fronts of most buildings of any consequence more or less of stonework is introduced, there is something harsh in the contrast between the red bricks and the cold colour of the stone; and even where no stone is employed there is always some wood used, which being often painted white, by no means lessens the objection. Graystocks match so much better with the colour both of stone and paint that they have obtained a universal preference in London and its immediate vicinity." It must, however, be added that villas and suburban residences built of red bricks with stone dressings are in the present day not at all uncommon.

At Hedgerley, a village near Windsor, red bricks about 1½ inches thick, of very firm texture, are made; they will stand the greatest violence of fire, and are called Windsor bricks, and sometimes *fire-bricks*.

Besides the foregoing varieties, the following must be mentioned, although some of them are not often seen now:—1. The ordinary *Paris brick*, which is 8 inches long, 4 inches broad, and 2 inches thick, French measure, which makes them rather larger than ours. 2. *Buttress or plaster bricks*, made with a notch at one end, half the length of the brick, used for binding work built with great bricks. 3. *Capping bricks*, used for the purpose which their name denotes. 4. *Great bricks*, used in fence walls; they are 12 inches long, 6 inches broad, and 3 inches thick. 5. *Cogging bricks*, for making the indented work under the capping of walls built with great bricks. 6. *Compass bricks*, of a circular form, for steyning walls. 7. *Concave bricks*, made flat on one side like an ordinary brick, and hollowed on the other; used for drains and water-courses. 8. *Dutch or Flemish bricks*, used in paving yards, stables, etc.; also for lining soap-boilers' cisterns and vaults. 9. *Feather-edged bricks*, made of the same size with the ordinary statute bricks, but thinner on one edge than on the other; they are used for pinning up brick panels in timber buildings.

Brick and tile paving is performed by the bricklayer. Brick paving is either flat or on edge, in sand, in mortar, or cement. Brick flat paving in sand—that is, with the bricks laid on their broadest surfaces and bedded in and on dry sand—is not to be considered strong or permanent; nor is flat paving in mortar much better, for if the soil on which the bricks are laid be at all light or sandy, they become loose by unequal pressure, water or damp is absorbed by the ground beneath, and the paving yields to the tread; in fact, thin mud sometimes collects underneath, which, as a brick is trodden upon, is pressed upward, and the floor is thus kept in a constantly damp, dirty, and unhealthy condition.

GREAT MANUFACTURES OF LITTLE THINGS.—VII.

LOCKS.

BY CHARLES HIBBS.

Remembering the ponderous machines upon which the artist metal-workers of the Middle Ages used to lavish so much wealth of decoration, it might seem that we are scarcely justified in placing the subject of this article among the "Manufactures of Little Things." But when it is stated that the average yearly production of locks in one district alone is not less than 25,000,000, of which by far the larger part are small till, cabinet, and pad locks, some of the latter being sold wholesale at the ridiculously low price of 2½d. per dozen, it will be seen that they have a fair title to be comprehended in this series. The district alluded to, which is the principal seat of the industry in the kingdom, comprises Wolverhampton, Willenhall, Walsall, Wednesfield, and several smaller towns in what is familiarly known as the "Black Country." Of these, Wolverhampton may claim to rank first, since here are made those qualities which combine scientific construction with high-class workmanship, and which are sold at high prices, varying from a few shillings each to several pounds. Here are the famous works of Messrs. Chubb and Son, whose make was estimated by Mr. J. C. Tildesley in 1866 to be 30,000 per annum, none of which were sold under ten shillings each. The reputation of Wolverhampton for lock-making is not of yesterday. Dr. Plot, writing in 1686, says quaintly: "The greatest excellency of the blacksmith's profession in this county lies in the making of locks for doores, wherein the artisans of Wolverhampton seem to be preferred to all others. . . . And these locks they make either with brass or iron boxes, so curiously polish't, and the keys so finely wrought, that 'tis not reasonable to think they were ever exceeded unless by Tubal Cain, the inspired artificer in brass and iron." Willenhall, on the other hand, is the chief seat of the *cheap* lock manufacture, and so exceedingly rapid is the process of production, that a Willenhall lockmaker is popularly said never to take the trouble of stooping to pick up a lock which he may happen to let fall, because it would take him less time to make another. The common and simple sorts are certainly put together with great celerity; the various parts being cut out with a press, the holes pierced, and the bright portions polished beforehand, so that they only require to be riveted together with a few taps of a hammer, and the touch of a file is scarcely needed.

Many curious specimens of ancient locksmiths' work still exist, remarkable for what our forefathers used to call the "pretty conceits" of their ornamentation and construction, which we have not the necessary space to describe. We must be content to refer only to such as will serve to illustrate our subject as we proceed. It is thought that the technical student will be most interested in following the various steps or stages of improvement in construction, which have enabled us to supplant the rude, heavy, and eminently unsafe locks of former times, by the complex and beautiful machines that now guard the doors of our merchants' and bankers' safes. There is not much to be said about the methods of manufacture, the skilled hand being the principal instrument used in the production of the better kinds of locks; but there is very much that is interesting in the history of the successive inventions which have been brought out with a view to secure the one desideratum—impregnability—and their defeats in detail by the efforts of the scientific lockpickers. Such mechanical or other contrivances used in the workshops as have novelty, we shall not fail to notice; but our principal object will be to convey to the reader's mind a clear idea of the mechanism of the locks themselves, from the earliest and simplest down to the latest and most intricate. In attempting this, we cannot pretend to do more than touch the main landmarks of the subject; we cannot describe all modifications of detail; but we shall endeavour to make clear the several changes of principle which have been introduced into lock-construction. To do this without diagrams will be difficult, but if the reader will give his attention we hope to succeed.

The ancient Egyptian wooden lock, which guarded the doors of Thebes, and which is in use to this day in Turkey and the East, may serve as a good starting-point for our inquiries. It is more like a bolt than a lock, and we shall best understand its description by keeping in our mind's eye the model of an ordinary door-bolt, working into a staple. The bolt itself was a beam of wood, and the staple was also a huge block of wood, cut away to receive the bolt, a similar block being fixed upon the door, for the bolt to slide in. When the door was closed, and the bolt shot into the cavity of the block that was fixed upon the jamb, the bolt mechanism proper was complete. Now for the locking. In the upper part of the block that was fixed upon the door had been bored, say three, vertical holes, in which lay loosely as many wooden pins, their lower ends resting on the top surface of the bolt. When the bolt was pushed as far as it would go into the staple on the jamb, in order to fasten the door, three corresponding holes, bored in the substance of the bolt itself, came immediately under the loose-lying pins, and they fell in by their own gravity. The bolt was therefore fixed until the pins could be lifted out again. A plate fastened on the top of the block prevented the heads of the pins being seen, or reached, from the outside. It should be understood that the pins were furnished with projecting heads which only allowed them to fall a certain distance. Now for the key. This was also simply a straight bar of wood, with pegs fixed near one extremity, corresponding in number and position to the locking pins. A longitudinal slot cut in the face of the bolt on the side nearest the door admitted this key, it being of sufficient height to allow the projecting pegs to pass. When the key was pushed to the end of the slot, the pegs being immediately under the locking pins in their holes, it was lifted up bodily, and pushed the pins upwards until they came flush with the top of the bolt. Then key and bolt together were drawn back until the fastening was released. So ponderous were some of these "locks," that the key was almost as much as a man could carry, and it was of this kind that the prophet Jeremiah spoke, when he prophesied, "The key of the house of David will I lay upon his shoulder." The reader is requested to bear this description in mind, as he will discover that this primitive device of the ancient Egyptians is the type of the modern tumbler-lock.

It will readily be seen that a door fastening like this, though not devoid of ingenuity, would present no obstacle to a modern house-lifter. Nothing would be easier than to ascertain the position of the pegs by taking an impression of them with a blank bar, properly waxed.

The next stage of improvement was properly the warded lock, about the date of whose introduction there is considerable doubt. Warded keys have been found at Pompeii, and among Roman remains at various places, differing very little in shape from those of the present day. The bolt was no longer of wood, massive and clumsy, but of metal, probably bronze, and of more reasonable proportions. It would also necessarily be enclosed in a box, in order that the wards might be affixed in their proper places and concealed, and so would bear sufficient resemblance to a modern ordinary warded lock to render a description of the latter sufficient for our purpose. Everybody is familiar with the action of the common back-spring door-lock, in which, by the turning of a key, the bolt shoots backwards or forwards with a jerk and a snap. The solid lump of iron which enters the receptacle on the door-post does not represent the thickness of the bolt throughout; inside the box of the lock it is cut away to a thin strip, and slides within runners fastened to the back plate. Out of the bottom edge of the strip is cut a semi-circular recess, called the talon, in which the key catches, and impels the bolt either way, according to the direction in which it is turned. A spring presses on the top of the bolt, and causes it to grind in its motion upon the edge of a stud, fastened to the back plate, the lower side of the bolt resting upon it at its hinder extremity, behind the talon. Two shallow notches cut in this part of the bolt, and the space between them smoothed and rounded, so that when the key turns in the talon, the bolt is lifted, as it were, out of one notch into the other. This causes the jerking motion that is felt in locking and unlocking the door. The projecting part of the key which works into the talon, and which is called the bitt, or web, of the key, is impeded in its revolution by certain strips of metal attached to the back plate, which render it necessary for corresponding clefts or slots to be made in the bitt, in order to pass them. This constitutes the ward arrangement, which may be as complicated as the artificer pleases. Some of the ancient locks had wards of the most intricate character. Upon the edges of the upright strips, which ran round the lock in the direction of the semi-circular sweep of the key, were fastened cross pieces of various shapes,

called bridge-wards, which required perforations to be made in the key resembling an anchor, a star, or some other artistic device. It will be obvious that in the case of a lock which has to be opened from either side, such as that of a street door, there must be wards upon both plates, and also that the wards upon the front plate must be exactly identical with those upon the back plate, or otherwise the key will not be reversible.

The great fault of the warded lock is that it may be very easily picked. Seeing that the only part of the key which really does the work of locking and unlocking is that end of the bitt which impinges upon the talon, it was only necessary to cut away all the middle part to escape the wards altogether. A lock might even be opened with a piece of bent wire, provided it were strong enough to overcome the resistance of the spring. To defeat this in some measure, wards were fixed which required a slit to be made in the *end* of the bitt; and in the case of a non-reversible key, wards of complicated shape were attached to the front plate of the lock, so that the perforations required to be started from both sides, and to run into each other in an intricate pattern that could not well be guessed. But however elaborate the defences, they were always to be overcome by a professional picklock, if only he could snatch an opportunity to take an impression of the wards with a blank key, coated with wax or soap, or even with the smoke of a tallow candle. Having secured this, he could make a skeleton key of the shape required, taking care that it should have a cavity wherever there was a ward to encounter, and the lock was at his mercy. In fact, he had only to carry a sufficient assortment of skeleton keys of different sizes and shapes, Z shape, M shape, etc., to be able to master almost any lock he might have the chance to operate upon.

Many devices were early resorted to for the purpose of increasing the security of the warded lock, such as that of introducing an alarum, etc.; but bolder inventors sought safety in departing from the principle altogether. The most curious example we have of a lock having neither wards nor key, is the letter-padlock, which appears to have been invented about the beginning of the seventeenth century. As it enjoyed a great reputation up to a late date, being used for the fastening of courier's despatch-boxes, coffers containing deeds, etc., where secrecy and inviolability were desiderated, and as it will serve admirably to illustrate a most important point in our present inquiry, it will be convenient here to describe it. In general appearance it resembled a barrel or cylinder, slung horizontally between the two ends of a bow. The bow, or shackle, was hinged at one end to the barrel, and when shut down was secured at its other end by a catch fixed on a spindle which passed into, and fitted, the whole interior length of the barrel. All that was necessary to open the lock was to draw out the spindle sufficiently to release the catch. The problem then was how to prevent any person, not the legitimate user of the lock, from drawing out the spindle. This object was effected by the following ingenious contrivance. On the spindle was a row of studs, set at equal distances in a line. A longitudinal slot in the barrel permitted the entrance of these studs, which were long enough to project through the slot, and to stand up a little above the exterior surface of the barrel. On to the barrel were now slipped a series of stout flat metal rings, each having a transverse groove at one part of its internal periphery, to enable it to pass the still protruding studs. The internal edges of each ring were also stepped or rabbeted all round, so that when all the rings lay close together on the barrel, these steps, joining, formed a cylindrical groove within which the stud would freely traverse, if the rings were turned round. The rings, therefore, being once passed over the studs, and moved round a little by the fingers, would effectually lock the spindle in the barrel, nor could it be withdrawn until all the rings were restored to that position in which the transverse grooves came together in a line. As the outside of the rings was smooth and even, and as they fitted accurately together, there was nothing to guide the fraudulent tamperer with the lock, as to the situation of the internal grooves, and he might not probably succeed by guess-work in a lifetime in getting them to the opening position. How, then, was the owner himself to manipulate the lock? Round the outer surface of each ring were engraved the letters of the alphabet, and only when the rings were severally turned round so that the letters forming a certain word came into line immediately under the bow would the lock open. These locks were alluded to by Beaumont and Fletcher, in the play of the "Noble Gentleman," and also by the poet Carew, who in one of his verses compares something to—

> "A lock
> That goes with letters, for till all be known,
> The lock's as fast as if you had found none."

The word, which must consist of as many letters as there were rings, might of course be selected by the owner when he ordered his lock from the smith. Thus, if there were six rings, he might choose the word *sesame* as the talisman. Having locked up his treasures, he had only to move the rings round indiscriminately until the letters were thrown into *pie*, and he might rest satisfied that no person ignorant of the magic word would be able to despoil him. But there was a flaw in the security of these early letter-locks, inasmuch as the secret of the opening cipher was at least shared between the owner and the locksmith, and the former might be surprised out of it by a stealthy watcher. A great improvement was introduced, it is said, by Regnier, director of the Musée d'Artillerie at Paris, about the middle of the seventeenth century. He made a lock with a double set of rings, one over the other. The outer rings, by means of movable studs, the position of which could be varied at pleasure, governed the movements of the inner rings, and thus the owner was enabled to set the lock to any combination of letters he pleased, or even to vary the combination from day to day, the secret resting only with himself.

This, slightly modified, is the letter-lock which has come down to our day. Looking to the enormous number of permutations that can be made in the alphabet repeated six or seven times, it might be supposed that the lock was impregnable, except to violence; it would at least seem to defy all the arts of the picker. So, at least, it was supposed, down to the dawn of the era of International Exhibitions. It was during the great world's fair of 1851, as our readers will remember, that the lock controversy, as it has been called, filled the pages of our scientific journals, and set all the mechanicians in the kingdom pondering upon the means of defying the skill of the professional violator. It was then that the celebrated American expert, Mr. Hobbs, made the memorable and alarming declaration, that *all* the locks which had hitherto been made in England admitted of being very easily picked. We have yet to lead up to the history of that famous picking of Bramah's lock, which had been hanging for half a century with a standing challenge to the mechanical genius of all the world, offering a large reward to whoever should open it without injury by any instrument except its own proper key. But to do this, we must thread our way, step by step, through the various improvements that were made in the original warded lock, by the introduction of tumblers, levers, etc., and we must endeavour to master the principle upon which the Bramah lock was constructed. To return to the letter-lock. One of these, of perfect workmanship, and of the most improved construction, was shown to Mr. Hobbs during a visit he was making to a celebrated lock manufactory. Its advantages were being descanted on—its entire independence of a key or other separate instrument—the length of time it would take to put it through its millions of permutations—and the consequent utter imposibility of getting it open by any illegitimate means—short of wrenching or sawing its parts asunder. As the conversation proceeded, Mr. Hobbs was turning the instrument about, apparently in an unconcerned manner, with his fingers, and in a few minutes from the time he first had possession of it, to the great amazement and consternation of those who were sounding its praises, he showed them the lock open in his hand. If a miracle had happened, they could not have been more astonished. From that moment all faith was shaken in the presumed impregnability of the permutating principle.

The manner in which Mr. Hobbs accomplished this feat was as follows:—He first applied pressure to the end of the bolt, or central spindle, in the direction tending to draw it out and release the bow. For the purpose of picking the lock, it is necessary that a continuous pressure should be exerted in this direction, pulling, as it were, against the interior obstacles presented to the withdrawal of the spindle with its studs. To a clever manipulator like Mr. Hobbs, there would be no difficulty in maintaining this gentle pressure with the fingers of one hand, even while curious eyes were watching his movements; under other circumstances a bent spring would best answer the pur-

pose. The spindle being thus acted upon, the interior studs, if the mechanism of the lock were absolutely perfect, would all be pressing equally upon the sides of the rings; but it was at that time practically impossible, even if its importance had been foreseen, which it was not, to make a lock with such extreme accuracy and nicety in its fitting parts as that some of the rings should not bind more than others. Mr. Hobbs then felt cautiously and delicately which of the rings was tightest, by which he knew that one of the studs was pressing against it. He then turned that ring very gently round until he felt the stud slightly jump into the transverse groove. Leaving it carefully there, he felt for the next tightest ring, and repeated the operation, and thus by turns, aided by a most delicate sense of touch, he got the transverse grooves all together in a line, and the spindle came out.

This description, if we have succeeded in making it clear to the reader's mind, will help him to understand the principles of attack and defence, if we may so express it, which are involved in the lock manufacture of the present day. The science of lock-making, at the period we speak of, passed through a phase which very much resembled that now going on in the science of warfare, the alternating triumphs of armour plates and projectiles. As the old locks were found to be unreliable, improvements were introduced, which for a time baffled the skill of the lock-picker; and then he, in his turn, by a new exercise of ingenuity, overcame the difficulties, and became master of the situation again. We shall endeavour to describe the principles of lock-making and lock-picking with equal minuteness, believing that it is of quite as much importance for us to know the weak points of our defences as the strong ones, and that it is a false policy to hide the knowledge of the vulnerable parts from ourselves, for fear of exposing them to an enemy, who probably knows them too well already. But this must be reserved for a future paper.

FORTIFICATION.—X.

BY AN OFFICER OF THE ROYAL ENGINEERS.

APPLICATION OF FIELD FORTIFICATION TO THE DEFENCE OF EXTENDED POSITIONS, INCLUDING VILLAGES, HOUSES, ETC.

BEFORE examining in detail the ways in which villages, groups of buildings, etc., can be hastily rendered defensible, and the principles on which the work should be done, it will be well to consider for a moment the circumstances under which an army would avail itself of the aid of fortification in the active operation of a campaign. It may safely be asserted that as a rule the defensive force is the less numerous of the two, and that it will endeavour to induce the enemy to fight on some previously prepared battle-field where the natural strength of the position (increased if possible by artificial means) will more than compensate for the numerical disparity between them.

Except under very exceptional circumstances, it will not suffice for the defenders to wait passively behind their defences, lest their position should be turned, and they consequently must often manœuvre in advance of their final position, so as to mask the existence of their own defensive arrangements, and to draw the enemy on to them unawares. The attack, on the other hand, having no fixed plan of operation beyond the strategic considerations of the campaign, will endeavour to force their weaker opponents to fight whenever a favourable opportunity occurs.

When the defenders have time, say two or three days at their disposal, and a strong position to defend which is difficult to turn (as was the case with the Russians at the Alma), it would seem almost criminal not to fortify and improve its natural advantages to the greatest extent. As that length of time is sufficient for the construction of formidable field-works, the nature of the defences need only be dependent on the slopes and character of the ground over which the attack must be made. The Russian position on the heights above the Alma had one flank secure, and the ground was naturally very strong in front, so that there can be little doubt that if it had been thoroughly intrenched, the loss to the Allies would have been much more severe than it was. Such favourable conditions as these, it need hardly be said, rarely occur, and it must often happen that an army is forced to fight with inferior numbers in a position offering considerable advantages to their assailants. In these cases it is that a practical knowledge of field fortification judiciously applied, may turn the scale in its favour, as the defender may so strengthen the points most inviting attack that he can hold in check large masses of the enemy with a comparatively small force, while with the remainder of his troops he is free to act when a favourable moment occurs.

Economy of strength and concentration at the vital points, coupled with the power of taking up the offensive at pleasure, are the principles on which the defence should be arranged.

The defending force has the advantage of being in possession of the ground on which the fight is to take place, and consequently can accurately determine its defensive capabilities. They cannot expect, however, in a very limited time to thoroughly fortify their whole line, and even if they could the attack would probably avoid a direct advance, and would assault in another direction a few hours later, for it is one of the great advantages possessed by the assailants that they are free to attack wherever they can find a weak point, whereas the defenders are more or less obliged to adhere to their works, unless they fight in the open at a numerical disadvantage.

The real difficulty of the defender, therefore, is to foresee the probable phases of the, as yet, undeveloped fight, and then to determine what points most require to be strengthened, and how far it is possible to do so in the time.

The best way of solving the difficulty would appear: firstly, to carefully ascertain the strength of your position as regards materials, labour, etc., for defensive purposes; secondly, to curtail the extent of front occupied to as great an extent as possible, so as to have a powerful reserve in hand after garrisoning the various points occupied; and thirdly, having generally sketched out your plan, endeavour if possible to examine your position from the enemy's point of view, by riding forward on to the ground on which his guns will probably be placed, and then consider how in his place you would best be able to attack it.

By this means many weaknesses and defects in your original scheme will be detected, and you will be able to notice the hollow ground and other spots where he will probably assemble the masses of his troops before making his assault. The position of these points being known and indicated, their distance should be ascertained from the intended position of your guns. Having now matured your plan, use every exertion to strengthen the principal points of your position, and to clear away round each anything likely to obstruct your fire, working outwards in every case. Endeavour to provide easy means of communication between one part of the line and another, and especially facilitate the movement of the reserve towards the threatened points. Theoretically an obstinate successive defence from house to house should be arranged, finally culminating at some large building where the reserves and remnants of the garrison may make a final stand. This, however, applies more to villages held as isolated posts than to those forming part of a general position, and, moreover, it cannot often happen that there is sufficient time for such complete arrangements. In any case it is obvious that it is of primary importance above all things to render it impossible for the enemy to get even a temporary possession of your outer line, for when their troops have once obtained a footing in houses, and behind walls, hedges, etc., the original conditions of the fight are reversed, and it becomes a serious and difficult matter to dislodge them.

A good accumulation of obstacles in front and round the points to be rendered especially strong, supplemented by the steady fire of infantry armed with breech-loaders, should render it almost impossible to force such positions, even with overwhelming numbers, unless the attack has been preceded by a heavy and accurate artillery fire. The advantages of the attack are doubtless very great, and some recent German writers hold that the defenders will be so demoralised by their necessarily passive attitude under a crushing artillery fire, that an assault in force must succeed. The results of the last war (1870), however, seem to point to an opposite conclusion, as the German lines of investment round Metz and Paris (consisting of villages in a state of defence) were never forced, although attacked on several occasions by large bodies of troops and a powerful artillery.

The distance between the strong points in the line should not be too great to prevent the intervening space being thoroughly defended by a cross-fire of musketry and mitrailleuses, and the

guns of the defence should be placed well in rear of the front line, so as to be out of danger of immediate capture, and in such positions that while they can defend the front and intervals between the fortified points in the line, they do not draw the fire directed against them on to the houses occupied by the infantry.

The plan of concentrating your force for the defence of certain spots has the defect that the enemy will concentrate his artillery on some of them, and endeavour to crush your defences and form a gap for the entrance of his assaulting columns, who would remain under the nearest cover until there appeared to be a chance of success; it must be remembered, however, that he would probably adopt exactly the same line of action in any case, and that if you can only manage to place your men under cover close at hand, and so diminish the casualties, you are in a far better position to repel an assault than if you had originally adopted a more scattered distribution of your force.

The effect of field artillery on ordinary farm and cottage buildings appears to be various, depending as it must on the nature of the masonry, and on whether time or percussion fuzes are used for the shells. Much valuable information has doubtless been obtained on this head during the late war in France, which is not yet published. It would seem, however, most certainly advisable to loophole and prepare for defence all buildings, walls, etc., to the fullest extent, trusting to be able to make use of some of them when the storm of shot and shell is over. Care should be taken that all means of forming banquettes on the outside are removed, and that the loopholes are at such levels as to be useless except from your own side of them. As, however, buildings that have evidently been loopholed, etc., would inevitably draw a large portion of the enemy's artillery fire preparatory to the assault, it would seem unadvisable to garrison them with more than a few picked marksmen, and a sufficient guard to extinguish the fires that are nearly sure to break out under a heavy shell fire.

The infantry should be posted under cover in a trench, or behind cover of some kind, a short distance in advance of the buildings, the ruins of which they will eventually have to defend. They are then on the spot and ready for instant action, but should lie down or be kept out of sight during the preliminary artillery duel, and until the enemy's infantry get within range.

They may be further protected from splinters of shells and stones, brickwork, etc., by a mound in rear of the trenches in which they are placed, which latter, however, must not be so deep as to give cover to the enemy if he reaches them. Every possible precaution must be taken against fire by the removal of thatched roofs and other inflammable materials, and by arranging supplies of water in buckets, etc., in each house or room. Where fire-engines are available they should be in readiness at some central point, and arrangements made for their water supply.

Ample reserves of ammunition must be provided in some convenient situation as secure as possible from fire, and yet stowed in such a way as to be capable of being readily moved in cases of conflagration. Communications or rough openings should be made from house to house, so as to facilitate the removal of the wounded and the bringing up reserves without the necessity of their appearing in large bodies in the streets, some of which are sure to be enfiladed. It has been very truly remarked by a recent German writer (Capt. Laymann) that one of the points in which the attack possesses the greatest moral advantage over the defence is the fact that whereas the former are constantly advancing, and consequently leave their dead and wounded behind, the defenders have to stand their ground and continue the fight amid the depressing influences of having their dead and wounded comrades round them.

To obviate this, organise as far as possible a regular service of stretchers, shutters, etc., with attendants, for each part of the line, so that the wounded may at once be moved, if not to a place of safety, at all events away from positions in which they can only tend to demoralise and increase the difficulties of those that remain at their posts. An efficient system of signals by day and night should be established, and the defenders of each post should clearly understand the following points: firstly, where they are to find their supports and reserves; secondly, where their ammunition reserves are; and thirdly, if forced to retreat, in what direction they are to retire. As the result of the action will depend on the successes at several of these points, this last instruction may have to be modified to suit the changes of the fight, and can therefore only be laid down in a general sense.

In wooded countries it will be essential to cut down considerable numbers of trees, to enable the defenders' guns to sweep the approaches to the position. This is a heavy work in itself, and requires not only numbers of men, but what are probably more difficult to find, large numbers of felling axes and other tools.

In cutting trees to serve as abattis, care should be taken that the trees are cut so as to fall in the required direction, and thus save the labour of moving them afterwards. There is perhaps no more impassable and therefore useful obstacle than a thick abattis of large trees, but the difficulty of getting them rapidly brought to the spot is excessive, as will be seen if we remember that to cut trees down rapidly they must be felled some three or four feet above the ground, leaving a stump of that height. After a few trees have been cut in a wood, it would be impossible to drag others past these stumps unless regular roadways are cleared. When trees are growing near buildings, and are not sufficient to form abatis, it will be better not to cut them down if they do not impede the fire of the defenders, as they serve as a screen from the enemy's view, and shells fired with percussion fuzes would burst on striking their branches.

It is of course impossible to do more than indicate generally what should be done. All the methods of forming obstacles, loopholes, trenches, etc. etc., that have been previously described, would now be applied in a rough, hasty fashion, to meet the circumstances of each case.

They should not, however, be applied along the whole line, but rather be multiplied to increase the strength of certain points only. This will enable the defenders to hold them with less troops, and leave open spaces through which, with their remaining forces and cavalry, they may advance. These spaces, though apparently open, would really be almost impassable for the enemy under a cross-fire of musketry and a direct artillery defence from the guns placed in rear of the line. The foregoing remarks apply to the case of villages held defensively by troops who have been in possession of them for at least a few hours, and when each village is part of a general line and is supported by troops, guns, etc., in rear. We must next consider them as isolated posts, and in what way they may be utilised if seized by troops for offensive purposes in an action.

PHOTOGRAPHY.—VII.

By J. C. Leake.

PRINTING (*continued*).

Having in our last article described the ordinary process of photographic printing, we may now proceed to describe such modifications thereof as are necessary in certain cases. Although the delicate and very smooth surface imparted to the paper by the application of albumen is most useful in securing very fine definition, the gloss which is at the same time obtained is often objectionable, especially in large pictures, and for certain subjects, such as the reproduction of engravings, books, or manuscripts. It therefore becomes necessary to make use of a process in which these defects may be avoided, and this we may now proceed to describe in detail.

One of the simplest and easiest methods of producing a plain paper print is to sensitise the reverse side or back of the ordinary albumenised paper; the whole of the subsequent processes being precisely similar to those already suggested for printing upon albumen. Excellent prints may, however, be produced upon paper which has been simply salted, and this is of course the readiest and most effective method, as well as the cheapest. In order to prepare paper for this process, a dish of glass or porcelain should be provided of sufficient size to hold the sheet, and at least three inches deep. A quantity of the following solution should then be prepared: Chloride of ammonium, five grains; distilled water, one ounce; dissolve, and filter into the dish for use. A sufficient number of sheets having been cut to the required dimensions, one of them should be laid upon the solution, and completely and carefully immersed by means of a glass rod. This operation may be continued until the whole of the sheets—or at least twelve—are inserted. The papers should then be turned over in a mass, and the first inserted sheet removed and suspended by one corner until dry. In some cases gelatine or arrow-root is employed in order to improve the

colour, and add to the depth and richness of the impression, without imparting any gloss to the surface of the paper. Of these two substances arrow-root is unquestionably the best; and for many purposes paper prepared with it is exceedingly useful.

The mode of preparing arrow-root paper is as follows:—Take half an ounce of fine arrow-root, and mix with cold water into a cream. Prepare the following solution: Distilled water, twenty ounces; chloride of ammonium, five drachms; dissolve, and boil; adding the arrow-root by degrees and with constant stirring. When cold, the mixture must be skimmed, and the clean paste will be ready for use. The boiling must be effected in a vessel of glass or porcelain, metal being inadmissible. The sheets are to be covered with the paste in the following manner: Prepare a smooth board about half an inch smaller each way than the required sheets of paper. Lay the paper upon this board, and secure it at the edges by means of drawing-pins. The sheet may then be covered with the arrow-root paste by means of a soft sponge, exercising the greatest care in the removal of all streaks and lumps, and in obtaining a perfectly even layer over the whole surface. The paper should then be perfectly dried, when it will be ready for the sensitising process. In the case both of the plain paper, and of that prepared as above described, a strong sensitising bath is necessary where the richest tones are required. From sixty to eighty grains of silver to the ounce of water will generally answer, but the increase to ninety or a hundred will be amply repaid by the increased depth and brilliancy of the resulting proofs. The toning and fixing of the print upon plain or arrow-root paper may be conducted precisely as we have already described for that which has been albumenised, except that in most cases the toning has not to be carried so far, from the fact that the impression is not nearly so red when removed from the printing-frame. It will mostly be found that the prints upon plain paper are considerably reduced in depth in the process of toning and fixing, and they should consequently be printed rather more than would be required if albumenised paper were employed. Either plain or arrow-root paper should be used within twelve hours of its being sensitised.

Although the processes just described are thoroughly reliable and easily worked, it will most probably happen that the tyro will, at one stage or another of his work, meet with certain failures arising from various causes, which we will now consider. One of the most common failures is that of imperfect toning of the proof—either in parts or altogether. Uneven toning may arise either from the partial adhesion of the proofs to each other, or from an uneven coating of albumen. Unless the paper be well albumenised, and the coating perfectly even, it will be difficult, if not impossible, to get prints of even and regular colour; and this is especially the case when very highly albumenised paper is employed. Of course the only remedy here is to employ another sample, although with careful treatment the evil may be reduced to a minimum. Paper at all liable to streak should be toned slowly, and in a solution which has been mixed some days before use. It should also be sensitised upon a strong solution of silver, and used as soon as dry. Of course, in the case of irregular toning through the partial adhesion of the prints while in the solution, the remedy is obvious; and as the evil is much more likely to occur when the bath is freshly mixed, and in its most active condition, the greatest care and diligence should be given to keep the prints constantly in motion while the operation of toning is in course of being effected. It will but rarely happen that the print refuses to tone altogether, but should this be the case it will indicate either that the quantity of silver is considerably reduced, that the paper is very bad indeed, or that the gold toning solution is out of order or too weak. Marbled and spotty prints are sometimes produced from imperfect albumenising of the paper, but much more frequently from an insufficient quantity of silver in the nitrate bath. The strength of this solution is very rapidly reduced, and frequent testing should be resorted to in order to ascertain the amount of silver abstracted, in order that it may be constantly replenished and brought to the standard strength.

The weakness of the silver solution is also a frequent cause of weak flat prints, which upon immersion in the fixing bath of hyposulphite of soda dissolve nearly out, and upon drying present a faded appearance. If the negative be of good quality, the edges of the paper which are not covered by the glass will most probably become bronzed during the exposure necessary to produce a vigorous impression. Should it be observed that this bronzing is difficult to produce, or cannot be obtained by any amount of exposure, it may be safely concluded that there is an insufficient quantity of silver present, and that it must be increased. If the paper be kept a long time between the sensitising and exposure, the silver will combine with the organic matter present, and produce the same result. From the same cause—namely, the keeping of the paper after sensitising—will arise a yellowness of the light parts of the proof, a defect which may also be produced by the use of a toning bath which has become intermixed with that used for fixing, or of a hyposulphite bath which has been used for fixing too large a number of prints. Want of proper definition or sharpness in parts of the picture is frequently produced from the insertion of the paper in an over-dry condition. After drying the sheets should be allowed to hang for half an hour at least in the dark room before being placed upon the negative.

In concluding this part of our subject, we may briefly recapitulate the essential rules for successful printing. In the first place, never use any paper but that of the first quality. Secondly, be exceedingly careful that the silver solution is of full strength, and perfectly clean and clear. Thirdly, be careful to remove the whole of the free nitrate of silver before proceeding to tone the proofs. And finally, use fresh hyposulphite for each batch of prints. It is also important that the operations of sensitising, printing, toning, and fixing should be performed as quickly in succession as may be, if possible the same day. If these precautions be adopted, there will be no difficulty in ensuring the most satisfactory results, both with regard to the appearance of the prints and their permanence.

FARMING AND FARMING ECONOMY.—XII.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

LIVE STOCK.

INTRODUCTORY REMARKS—HORSES—VARIETIES OF—GENERAL AND SPECIAL MANAGEMENT OF—COST OF, PER ANNUM AND PER ACRE.

WE now approach a most interesting part of our subject. Britain is unrivalled both in the rich diversity and high quality of her live stock. Her cattle, sheep, pigs, and horses are sought for in every civilised country, and the keen competition thus engendered has raised the prices of the best-bred animals to almost fabulous sums. In the summer of 1870 two heifers left our shores for Canada, having been purchased for the enormous sum of 2,500 guineas, and in the November of 1871 their two calves were imported from Canada by a Scotch nobleman, Lord Dunmore, for the same sum as had been given for their dams. Even higher prices are given in America and New Zealand for the best strains of English blood, and we are at a loss whether to look upon the keenness of the competition as the result of a "fancy," or to allow the intrinsic value of the purchase to be thus correctly gauged.

Great Britain has always been rich in her many breeds of stock. In the latter quarter of the last century attention was directed towards their improvement, and simultaneously we find Bakewell bringing out his new Leicester sheep, long-horn cattle, and heavy horses; the Collings, Booths, Maynards, and others cultivating the form and aptitudes of the Durhams or Shorthorns; Weyman, Tully, Hewer, and Westcar working upon the Herefords; Ellman improving the South-down sheep; M'Neil taking in hand his West Highlanders in the remote Hebrides; and Quartly and Davy promoting the North Devon cattle.

Every recognised breed is an improved one, representing an expenditure of patience, skill, and capital rarely equalled. The pedigrees of pure-bred animals are kept with the greatest care, and the breeders of Shorthorns, Herefords, Devons, Sussex, and Polled Angus cattle, each have their herd-book. If we examine the exhibition catalogues of the Royal and Highland Agricultural Societies, we find prizes offered for ten breeds of cattle, twelve breeds of sheep, and four breeds of pigs, and besides these there are many other varieties of less general interest, but much appreciated in their own localities. There are also some excellent crossed breeds. A proper knowledge of live stock requires us to study the best means of breeding, rearing, and fattening animals, and it is to these parts of the

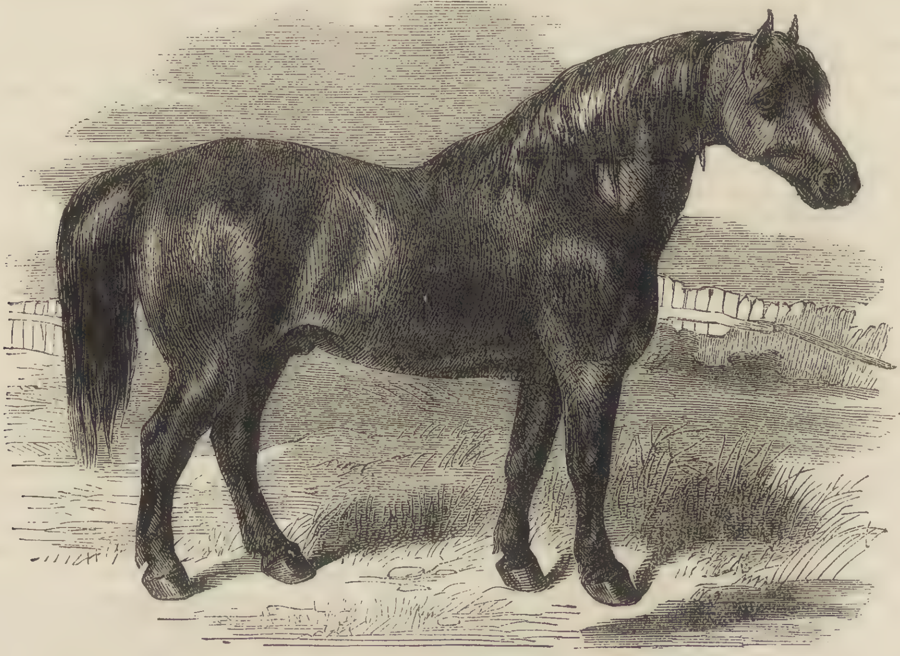
subject that our attention will be chiefly directed. Our standpoint must be that of the breeder, the grazier, and the butcher.

When we study horses it will be with reference to their working powers, and the best way of economising and developing them; the best methods of feeding and management, and the cost of their maintenance. Cattle will be considered as producers of beef and milk; sheep as growers of wool and mutton; pigs as manufacturers of pork.

PRINCIPAL BREEDS OF HORSES.

First let us take a rapid glance at the four principal breeds of agricultural horses.

The *Suffolk Punch* possesses a better combination of strength, compactness, and activity than any other breed. Height at shoulders 15 to 15½ hands; frame characteristically compact; barrel, round; colour, uniformly chestnut, though sometimes sorrel; said to be rather more liable to strains of the sinews and ligaments than other breeds. (Spooner.) Youatt informs us that this breed originated in a cross between the Norman stallion and Suffolk mare; that "the true Suffolk, like the true Cleveland, is now nearly extinct;" and that the present breed "is a cross with the Yorkshire half or three-fourths bred."



THE SUFFOLK PUNCH.

The *Clydesdale*, says Youatt, "owes its origin to one of the Dukes of Hamilton, who crossed some of his Lanark mares with stallions which he had brought over from Flanders.

Spooner informs us that they stand about 16 hands high, are extremely active, and very fast walkers, and that their faults are a tendency to lightness of body, and too great length of leg. A pair of Clydesdale horses will plough a larger breadth of land than any other kind of horse, but they require to be well fed. (Spooner.) The colour is black, grey, or brown.

The *Heavy Black Horse* is chiefly bred upon the rich pastures of Lincolnshire, and the Midland counties. At two years old many of them are purchased by Surrey and Berkshire farmers, who work them moderately, and sell them at four years old for the London market. They are fine-looking animals, and are purchased for show by wealthy brewers, who vie with each other in the magnificence of their teams. The colour is not restricted to black, but varies to grey and brown. The largest specimens of this breed are used for dray-horses. The next in size are sold as wagon-horses, and a smaller variety, with more blood, is used for mounting a considerable part of our cavalry, and also for drawing hearses. (Youatt.)

The *Cleveland Bay* is found principally in Lincolnshire, Yorkshire, Durham, and Northumberland, and is there used occasionally for agricultural purposes. The pure breed is, however, seldom seen, it having been crossed with three-fourths and thorough-bred sires for the purpose of breeding coach-horses. As the name implies, these animals are bay, with black points, and free from long hair at the fetlocks.

A large proportion of the horses used in agriculture are not of any pure breed, but of more or less mongrel character. We would recommend horses of medium size, from 15 to 16 hands high, active, and with a "dash of blood," as best adapted for ordinary farm-work.

The subject of breeding horses, although interesting and important, we must dismiss with few words. As in the case of breeding other descriptions of live stock, the pedigree, parentage, and the pasturage must all be considered. A good line of blood, parents faultless in form and faculties, in prime of life, and free from disease; pastures calculated to develop the good qualities transmitted, are all equally important conditions, and when they are observed, risk of failure is reduced to a minimum.

MANAGEMENT OF HORSES.

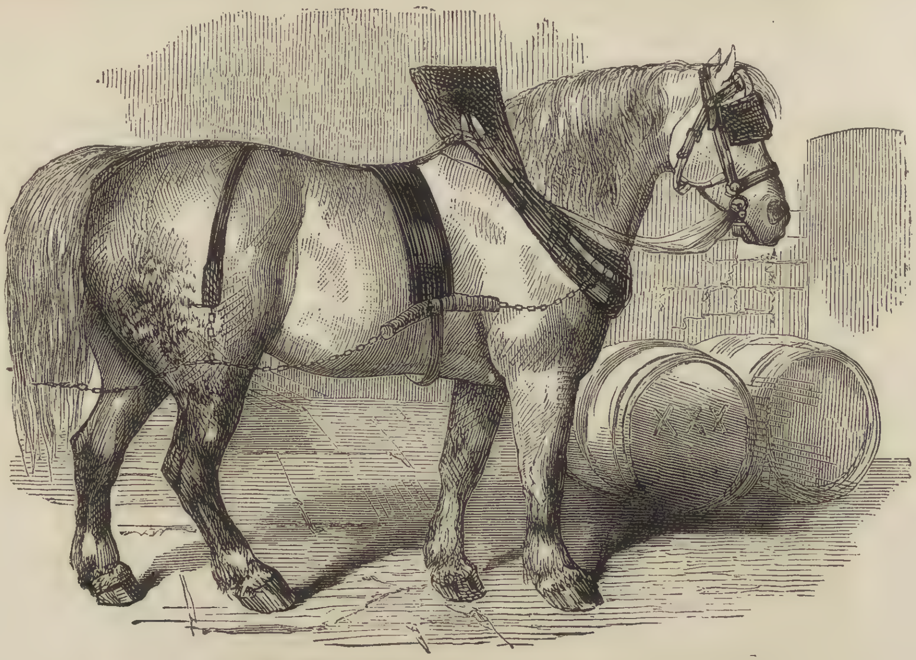
The health of farm-horses greatly depends upon their management. They must be provided with stabling affording sufficient warmth and shelter; they must be properly shod; cleanliness must be enforced; the horses must be thoroughly dressed down night and morning; food and water must be supplied regularly, in proper quantities and at proper times; and the importance of air and proper temperature must not be lost sight of.

The special management principally involves a correct system of feeding. The amount and character of the food given varies with the season and the work in which the horses are engaged. The agricultural year is divided as follows:—first, from the end of harvest to the beginning of winter; second, winter; third, spring and early summer, terminating with the sowing of turnips; fourth, hay and corn harvest. In the first and third periods the horses are constantly employed in work of an arduous character, such as autumn cultivation of fallows, wheat sowing, and afterwards spring corn sowing, and preparing for root-crops.

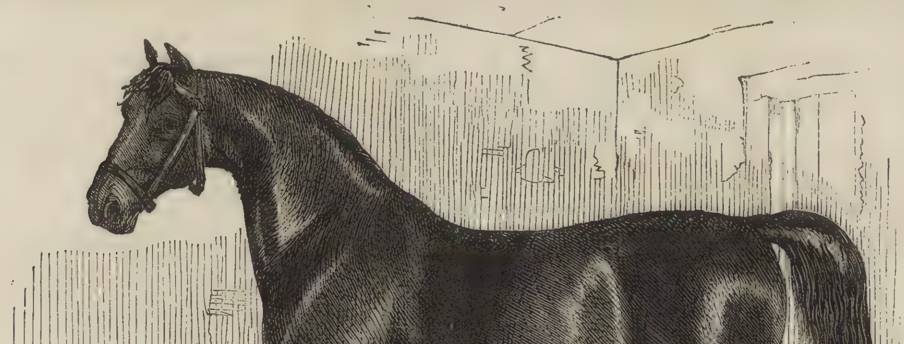
At such times the feed must be liberal, and 2 bushels of oats, half a bushel of beans, and 100 lb. of hay per week, will be an ample allowance.

Mr. Morton has collected, in his edition of Arthur Young's

"Farmer's Calendar," a large number of dietaries employed by well-known agriculturists. From among these we select the following amounts per week:—168 lb. hay, 63 lb. oats, 33½ lb. beans (W. Gater, Botley); 112 lb. hay, 84 lb. oats, 224 lb. beans (W. C. Spooner); hay *ad lib.*, 84 lb. oats, 10 lb. beans, straw straw-chaff may be given. The following weekly allowance of food in actual use at this season may be added:—112 lb. hay, 52 lb. oats, 70 lb. swedes, and 2 bushels of straw-chaff (S. Druce); hay *ad lib.*, 52 lb. oats, 17 lb. beans, 84 lb. swedes, straw-chaff *ad lib.* (C. Howard); 49 lb. of hay-chaff,



GREY VARIETY OF THE HEAVY BLACK HORSE, OR DRAY-HORSE.



THE CLEVELAND BAY.

ad lib., and ⅓ bushel of bran (A. Ruston); 168 lb. hay, 70 lb. oats, 14½ lb. beans, 24 lb. bran (A. Simpson, Beauly).

After wheat-sowing and throughout winter the amount of corn may be reduced, and a few swedes or mangels and

70 lb. oats, 210 lb. mangel, and straw-chaff *ad lib.* (J. J. Mechi).

In the spring, a similar amount of food as that supplied in the autumn is given. In summer, the principal modification

consists in introducing cut clover, vetches, etc., or in turning the horses out to grass. Under these conditions horses often lose their relish for corn, and in most cases the amount is reduced. From 1 to 2 bushels of oats (40 to 80 lb.) and cut green food *ad libitum*, are quantities given by good agriculturists.

Scarcely less important than the quantity of food, is the method of feeding. Three systems, each with modifications, include the various plans recommended:—first, feeding with unbruised and uncooked corn, and unchaffed hay; second, manger feeding, in which the hay and straw are chaffed and mixed with the corn, all being given in the manger; third, cooking food. The first of these is the oldest and most general; the second is less fatiguing for the horse, and has been found truly economical; the third is of doubtful merit, but is strongly believed in by many persons.

Lord Londonderry was one of the first who adopted manger feeding, and the result of his experience is thus given by Mr. Caird in his "English Agriculture in 1850-1." "Previous to the introduction of this plan, the ordinary feed for pit-horses was 3 bushels of oats, and 12 stones (168 lb.) of hay per week, and for wagon-horses 3½ bushels of oats and 14 stones of hay. After chaffing was employed, 2 bushels of oats and 7 stones of hay was found sufficient for the pit-horses, and 2½ bushels of oats and with 8 stones of hay for the wagon-horses." Upon the Royal Agricultural College Farm, Cirencester, the system of feeding is as follows:—All food given in the manger; no hay supplied; horses fed three times a day, namely, from 4 to 6 a.m., 11 to 1 p.m., and 5.30 to 7 p.m., and they are watered half an hour after coming in from work. The year is divided into two portions, the first from Michaelmas to May, the second from May to Michaelmas. During the first or winter half, they receive 1¾ bushel of oats, ¼ bushel of beans, 1 bushel of brewers' grains, and about 21 lb. per day of straw chaff (chop). During the summer half they have 1 bushel of oats, ¼ bushel of beans, and green food *ad lib.*

COST OF MAINTENANCE AND OF HORSE-LABOUR PER ACRE.

The cost of maintaining a farm-horse has been frequently estimated as about £30 per annum. Taking the average of 13 cases recorded by Mr. Morton, the cost for food alone per week appears to be 9s. in spring and summer, and 9s. 6d. in winter, or £24 1s. per annum. Assuming these figures as fairly representing this important item, we must add the following as entailed in the maintenance of farm-horses:—

	£	s.	d.
Cost of food	24	1	0
Shoeing	0	13	0
Repairing and furnishing gears . . .	1	5	0
Interest on a capital of £30 at 5 per cent. .	1	10	0
Deterioration and risk at 10 per cent. .	3	0	0
	£30	9	0

Some writers in estimating the cost of maintaining a farm-horse include the cost of keeping up the necessary implements, and the wages of the teamsmen. We, however, prefer to debit the horse with what immediately concerns him, and to open separate accounts for manual labour and implements.

Having ascertained the cost per annum, the next point of interest is the cost per acre, from which we may deduce the proportion of the farmer's capital invested in work-horses.

The number of horses required to work a given area of land will vary according to the proportion of arable to pasture land, the rotation of crops followed; the tenacity of the soil; the extra assistance derived from steam; the distance from markets and railways. Horse-labour on pasture-land is so small that we may leave it out of our calculation. The rotation followed is at once seen to be important, especially if it involves land remaining two or three years under grass. It is, therefore, usual to speak only of the number of acres of fallow land a team is capable of working, and not of the entire number of acres of arable land it can cultivate. Thus, it would be more correct to speak of a pair of horses being able to work fifteen acres of fallow than sixty acres of arable land. They will work the fifteen acres of fallow and carry on the work upon the other sections of the farm without difficulty. In other words, if the farmer has a sufficient force of horses to work his fallow and root land, he will find no difficulty in dealing with his corn and other crops. The following table will best illustrate the application of this principle, and at the same time show the number of horses found necessary upon some well-known farms of very different character.

TABLE SHOWING THE NUMBER OF HORSES EMPLOYED TO WORK FARMS OF VARIOUS CHARACTER IN DIFFERENT COUNTIES.

Farm and Locality.	Quality of Soil.	No. of Acres of Arable Land.	No. of Horses kept.	Acres in Roots or Fallow.	No. of Ac. of Fallow worked by each Pair of Horses.	Remarks.
Royal Agricultural College Farm, Cirencester	Light, brashy, and stronger loams	431	10	100	20	Occasionally employs steam cultivation.
Home Farm, Holkham Park . . .	Light, sandy	1300	42	325	15½	32 horses and 20 bullocks, 2 bullocks considered = to 1 horse.
Paston, Northumberland	Dry turnip soil	500	16	100	12½	Northumberland 5-course.
Leyfields, Notts.	Stiff clay	230	9	43	9½	
Bainess, Catterick, Yorkshire . .	Friable turnip soil and some stronger land . . .	381	12	95	15⅚	
Farningham, Kent (R. Russell) . .	Clay	1600	66	400	12	4-horse land, Howard's ploughs.
1st Prize Farm, 1871. Mr. Forester (Sherlow Farm, Shropshire) . . .	Moderately friable . . .	300	9	75	16⅔	
2nd Prize Farm, 1871. Mr. Winterton (Alrewas, Hays, Lichfield) . .	Moderately friable . . .	408	11	100	18⅕	Occasionally employs steam.
Holderness, Yorkshire (Caird's "English Agriculture," p. 302) . . .	Stiff land and bare fallow . .	400	13	66	10	6-course rotation.
Wittering, North Hants	Very light	480	12	120	20	
		6030	200	1424	14·24	

The average number of acres of fallow worked by a pair of horses in the above table is 14·24, and the amount of arable land 60·30. In order, then, to come to a conclusion as to the cost of horse-labour per acre, we have merely to divide the cost of maintaining a team, by the number of acres it is able to work. Thus, in the average of the above cases,

$$\frac{£60}{60·3 \text{ acres}} = £1 \text{ per acre.}$$

There are extremes as well as a mean. Accordingly we find in the case of Mr. Parkinson's farm at Leyfields 1 pair of horses only able to prepare 9½ acres of fallow, and 51 acres of arable land, while Mr. Sharpley of Wittering was able to work 20 acres of fallow and 80 acres of arable land with the same power. In the first case we have the cost of horse-labour thus represented:—

$$\frac{£60}{51 \text{ acres}} = £1 \text{ 3s. 7d. per acre.}$$

And in the second case—

$$\frac{£60}{80 \text{ acres}} = £0 \text{ 15s. 0d. per acre.}$$

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIV.—JOHN NAPIER, MATHEMATICIAN.

BY JAMES GRANT.

John Napier, Baron of Merchiston, the celebrated inventor of the logarithms, the greatest boon perhaps which genius could bestow upon a maritime empire, was born in 1550, during the reign of Mary, Queen of Scots, in the old castle of Merchiston, then situated on a solitary moorland near Edinburgh, but now incorporated in one of the suburban streets of the city. He was the ancestor of all those Napiers who in our own time have been so distinguished by land and sea, and was descended from an ancient family that had long been settled in the shire of Dumbarton, where they held lands under King Robert I. John, the inventor, was the eldest son of Sir Alexander Napier of Merchiston, afterwards Master of the Mint to James VI., by his first wife, the daughter of Sir Francis Bothwell, a Lord of Session; and, singular to say, at the time of his birth his father was barely sixteen years old. Though styled *Baron*, Napier was merely the laird or proprietor of Merchiston, as in Scotland men of that class sat in Parliament under the denomination of lesser barons.

He was educated at St. Salvator's College, in the city of St. Andrews, where he matriculated as a student in 1562. He afterwards spent several years travelling in France, the Low Countries, and in Italy, where a Doge of Venice presented him with the gold filagree box, in which, after his execution in 1650, the heart of the Marquis of Montrose was enclosed.

In the *Proceedings of the Royal Asiatic Society* for 1835 it was stated that "it appeared by the papers of John Napier, the mathematician, that he had, from the information obtained during his travels, adopted the opinion that *numerals* had first been discovered by the College of Madura, and that they had been introduced from India by the Arabs into Spain and other parts of Europe;" but it is unfortunate that the papers containing this fact so interesting to science perished by fire ere they could be printed.

On his return to Scotland in 1571, though a civil war was raging, he applied himself closely to the study of mathematics, and it is conjectured that he acquired a taste for this branch of learning during his residence abroad, more particularly in Italy, where at that period there were many mathematicians of high reputation; and though his solitary tower on the moor was often attacked, taken and retaken by the king's men and queen's men in succession, and more than once cannonaded, he had therein his study, which is still extant; and there (like Bacon, Schwartz, Galileo and others), "he had his little laboratory, his little forge, his crucible and phials, acids and essences, all the rudiments of science, with some faint foreshadowings of his noblest discoveries."

The age and the country were prone to superstition, so Napier speedily won the then unenviable and perilous reputation of being addicted to sorcery. He certainly believed in the discovery of hidden treasure by the use of a divining rod, and there is still in existence a contract drawn up between him and Sir Robert Logan of Restalrig (the famous Gowrie conspirator), concerning a search to be made for gold supposed to be "in the said Robert's dwelling-place of Fastcastell, hid and hoardit up secretlie, quilk as yet is unfound by ony man." For the discovery of this treasure Napier was to have a third of the hoard, with a safe armed escort back to Merchiston; but the affair of the Gowrie conspiracy against the king's life put an end to the speculation. Napier was alleged to hold secret correspondence with the devil, and to have a familiar spirit, in the shape of a *black cock*, which sat on the back of an arm-chair in his study; but this, and other stories concerning him, were the result of the ignorance of the age and his own Rosicrucian propensities.

When at college in his boyhood he contracted an intimate friendship with a Roman Catholic student, with whom he had many religious discussions in defence of the Reformers and their doctrines. At that time he was an attentive hearer of the sermons of "that worthy Englishman, Mr. Christopher Goodman," who had fled to Scotland after having given offence alike to Mary of England and her successor Elizabeth.

Goodman's interpretations of the Apocalypse and its mysteries, as applied to Catholicity, so impressed the mind of Napier, that, relinquishing his mathematics for a time, "he determined," to use his own words, "with the assistance of God's Spirit, to employ his skill and diligence to search out the remaining mysteries of that holy booke." So, soon after he published at Edinburgh, in 1593, his "Plain Discovery of the whole Revelation of St. John." This work he dedicated to James VI., and urged "His Majesty to attend to the enforcement of the laws, and the protection of religion, beginning the work of reformation *in his own house, family, and court.*"

Amid his mathematical studies, it would appear that Napier paid some attention to the cultivation of poetry, for prefixed to his work is a metrical address to "Antichrist," and certain versified prophecies out of the Oracles of Sybilla. The same year found him appointed by the General Assembly of the Scottish Church, one of the commissioners appointed to assemble at Edinburgh, with reference to certain designs alleged to be formed at Rome for the overthrow of the reformed faith.

In 1596 he published a letter to Anthony Bacon (brother of the famous Lord Bacon), entitled "Secret Inventions Profitable and Necessary in these Days for the Defence of this Island, and withstanding Enemies to God's Truth and Religion," the original MS. of which is preserved in the library at Lambeth Palace.

This work had direct reference to Spain and the Armada, and re-introduced the ancient classic idea of burning-glasses, together with other strange devices, among which were a piece of artillery to shoot in *curved* lines, cross-bar or chain shot to cut away "the whole masts and tackling;" a round chariot of iron (the *iron turret* of the present day) made "double muskett proofe," ships for sailing *under the water*, "with divers other strategemes," he concludes, "for harming of the enemy, which, by the grace of God and worke of expert craftesman, I hope to perform." But the age was not one of progress, and his suggestions fell to the ground, like those of many inventors.

For several years he had turned his attention to the discovery of a quick and short method of calculation, to facilitate the solution of trigonometrical problems, and at length his efforts were crowned by the most complete success. In 1614 he produced his book of logarithms, styled by Sir John Leslie "the noblest conquest ever achieved by man." This work, entitled "Mirifici Logarithmorum Canonis Descriptio, etc., authore ac inventore, Johanne Nepero Barone Merchistonii, etc., Scoto," was printed by Andro Hart, of Edinburgh, and dedicated to Prince Charles, afterwards Charles I. The Scottish mathematician thus attained that which the schools of Greece and the lights of Germany had failed to accomplish.

Logarithms in calculation are what the steam-engine is in mechanics. They enable the calculator to overcome every obstacle, and render the most intricate combinations of numbers comparatively easy. Before the time of Napier, philosophers devoted days and weeks to computations, which now may be accomplished in a few hours. The world suppose mathematicians to be mere calculators; but few men calculate less, if the number of characters employed be considered. By the aid of logarithms they are enabled with a very few figures to compute quantities which would utterly baffle the ordinary mathematician. Their use shortens nearly every arithmetical calculation.

"Though logarithms," says Professor Playfair, "had not been invented by Napier, they would have been discovered (eventually) in the progress of algebraic analysis when the arithmetic of powers and exponents, both integral and fractional, came to be understood. The idea of considering small numbers as powers of one given number would then have readily occurred, and the doctrine of series would have greatly facilitated the calculations which it was necessary to undertake. Napier had none of these advantages, and they were all supplied by the resources of his own mind." And it is a proud reflection for Britain, as a great maritime nation, that she does not owe to a stranger the creation of that intellectual aid, which renders her fleets as free and as fearless in navigation as they have ever been in battle; but to an obscure Scottish gentleman, born and bred amid the civil wars of the sixteenth century.

This important discovery made the name of Napier known to the learned over all Europe; and Kepler dedicated his "Ephemerides" to the inventor of the logarithms, whom he deemed the greatest mathematician of the age.

In his last work, entitled "Rabdologia, seu Numeratio per Virgulas," in two books, published in 1617, the year in which King James revisited Scotland, he describes a method of performing operations of multiplication and division by a number

of small rods, which continue to be known and used by the name of "Napier's bones."

Agriculture occupied some of his attention, and he had a plan announced for making land more profitable, by sowing it with salt; but as this was supposed to be the suggestion of the devil or the black cock before mentioned, the Scottish farmers were in no hurry to adopt it.

"When you have sown your white seed," he wrote, "you may sow for every boll of wheat, upon reasonable stiff or clay-land, one half boll of salt thereupon, and in sandy ground one firlot of salt; and let all be harrowed together, and hereby, God willing, you may have a good clean crop. In like manner when you have sown your oat-seed, you may sow three firlots of salt upon every boll of oats; but this must be done upon watery or laigh (*low*) land only, as upon meadow land, whereupon the water stands commonly in winter, ye shall, God willing, find a rich crop. But upon dry land ye shall sow no salt, where the oat-seed is presently sown, but before Martinmas, except with wheat, as said is, else ye shall rather lose than gain. Ye shall sow no salt with bear (barley) instantly neither upon wet nor dry ground, but as long before Martinmas as you may, as said is."

Napier was twice married; first in 1571, to Elizabeth, daughter of Sir James Stirling, of Keir, by whom he had a son, Archibald, afterwards first Lord Napier, a zealous Cavalier and adherent of King Charles; and secondly, Agnes, daughter of James Chisholm, of Cromlix, in Perthshire, by whom he had five sons and five daughters. One of the daughters, Margaret, became the wife of Sir James Stuart, of Rosythe, who is said to have been thus connected with the family of Oliver Cromwell.

On the 3rd of April, 1617, this illustrious mathematician died in his old patrimonial tower of Merchiston, which is now occupied as one of the principal schools in the Scottish metropolis, and was buried in St. Cuthbert's Church, outside the western gate of that city.

His eldest son, who succeeded him, was for his services and loyalty created Baronet of Nova Scotia by Charles I., and in 1627 was raised to the peerage of Scotland by the title of Lord Napier, which continues to be borne by his descendants.

A tomb belonging to another family, on the north side of St. Giles's Church, by popular error is always styled the resting-place of the great inventor, simply because it bears the name of Napier. Several portraits of him have been engraved from the original, which is preserved in the University of Edinburgh, and was painted in 1616, by whom unknown, but it was presented to the Senatus by his descendant, Margaret, Baroness of Napier, to whom his honours opened in 1686.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VI.—CLASSIFICATION OF EXHIBITS (*continued*).

THE system of fixing certain days for the delivery and removal of goods to and from particular classes, prevents the universal confusion that would prevail if exhibitors and their assistants belonging to all classes were allowed to bring in or remove their exhibits at one and the same time.

It was proposed in 1871 to extend a series of International Exhibitions over a period of ten years, so that each class of the manufacturing sections might be brought under review decennially, according to a scheme laid down by Her Majesty's Commissioners for the Exhibition of 1851. The divisions for scientific and new discoveries of all kinds, and fine arts, were, however, to occur *annually*, so that the public might be kept informed of the latest efforts in science and art. The International Exhibitions of new and rare plants, and of fruits and vegetables, showing specialities of cultivation, were also to be held annually by the Royal Horticultural Society in conjunction with the above exhibitions. But in 1874, at a special meeting of the Commissioners for the Exhibition of 1851, it was determined that the annual International Exhibitions should be discontinued after the closing of that which was then open to the public. The determination thus arrived at was one which, when announced, created no great surprise, for it had been evident that the public interest in these displays had been falling off year by year. Various causes might have been assigned for this. One, no doubt, was that the international display lost all its grandeur, and a great part of its attractiveness, by being confined to a series of buildings in which space was very limited, instead of massed in an imposing edifice like that of 1851 or 1862. The display, in fact, had dwindled down to something like that which might be seen in a series of ordinary shops of a respectable class, and all the general effect of which a large array of costly articles is capable was lost by their dispersion. Again, the exhibitions had recurred so frequently of late, that they ceased to excite any part of the interest which their novelty alone had previously created. And a further weighty reason for their discontinuance was found in the fact that our manufacturers were discontented with the arrangements which had been made with foreign exhibitors for the display and sale of their goods, which they considered placed the British producer at a disadvantage. So it has happened that the close of the London International Exhibitions, as they were lately arranged, has been witnessed without dissatisfaction on the part either of the manufacturers or the public.

Thus far I have endeavoured to give a digest of the general principles of construction,* arrangement, and management that recommend themselves for imitation at future exhibitions, and such comments on matters that demand correction, as my experience as a contributor to all our exhibitions from 1851 suggests. Among the multitude of details that demand attention for the satisfactory working of an undertaking of this nature, together with the conflicting interests that have to be considered and humoured, errors of judgment are sure to arise. Faults of arrangement and management can, as a rule, only be discovered after they have been carried into practice, but then both exhibitors and officials ought to endeavour to eliminate whatever has proved unsatisfactory, and profit by what experience has shown to be good, never forgetting to discuss the differences of opinion that may arise from their respective stand-points with mutual forbearance and courtesy.

In concluding the subject of International Exhibitions, it may not prove unprofitable to consider whether the buildings that have been erected at South Kensington might not be modified for future exhibitions, so as to correct some of the shortcomings noticed in a previous article.

The present building consists of long galleries forming three sides of a square, connected by two curved covered ways with the conservatory of the Horticultural Society, and by that with the Albert Hall, the garden of the Society being enclosed by the entire range of these structures. Between the "Exhibition Galleries" and the gardens run a parallel range of open arcades, used in 1871 for the coarser kinds of pottery, gymnastic and boating appliances, refreshment bars, etc. The galleries are two storeys high, the upper floors in each being devoted to pictures, statuary, and other works of art, which at various points give access to the roof of the arcades, that serves as open-air promenades overlooking the gardens. The ground between the Albert Road and the west galleries is quite unoccupied, and that between the east galleries and the Exhibition Road only partly covered by the buildings devoted to the French Annexe and the Council Room and Floral Bazaar of the Horticultural Society, while the South Gallery is a long narrow structure forming a remnant of the Exhibition building of 1862.

Regarding it as possible that the Royal Horticultural Society could find accommodation for their council-room and offices in the Albert Hall, the curved covered ways on the ground floor could most appropriately be devoted to a floral or horticultural bazaar. The ground between the west and east galleries and the public roads could then be occupied by additional dwarf (or one-storeyed) galleries and covered ways next the Albert and Exhibition Roads, for the convenience of carriage visitors, as an especial provision for wet days—a shortcoming greatly felt in the arrangements for 1871. Thus, on the day before the close of the Exhibition the rain came down in torrents, especially at the hour when the visitors were being "rung out," and the wind drifted the rain through the large open carriage entrances of the Albert Hall in drenching showers of spray. Crowds of handsomely-dressed ladies, waiting for their carriages to come up, were forced by the police, *under the orders of the door-keeper*, from the shelter of the hall, and the supply of public conveyances being quite inadequate to meet the demand

* For details of construction of Paxton's system, see Vol. I. of the "Illustrated Official Catalogue" of the Great Exhibition of 1851.

at this point for shelter at any price, the mass had no help but to "grin (rather svaagely !) and bear it." Common sense indicates that provision should be made, when there are large assemblies of people, against health or dress being injured during wet weather. Such accommodation ought to be arranged for at future exhibitions, if any further ones are to be held. The dwarf galleries on the west side could be arranged for the permanent features of the annual series of exhibitions—viz., machinery in motion and new mechanical and scientific inventions, while those on the east side could be employed for the requirements of other but varying classes, specified for each year's exhibits. These galleries run in unbroken parallel lines, a form of construction best suited for carrying out the proposed arrangement of the subdivision of *each class* into *nationalities*. The space that apparently is required for carrying out this reform would thus be provided and waste land utilised. While the outer walls next the public road, east and west, might be of brick, the internal supports might be arranged in the elegant iron-work adopted in 1851, and be roofed with glass on Paxton's ridge-and-furrow system, as may be seen at the Sydenham Palace.

The western and eastern arcades and galleries should likewise be made continuous for the class-divided-into-nationalities system, so that all the class galleries, whether on ground or upper floor, should merge into a grand hall, that could be erected across the lower end of the Horticultural Society's Gardens, in the position occupied by the Exhibition Building of 1862, where the galleries behind the dining-rooms now stand: that would repeat the best features of 1851 and 1862, the want of which, as previously stated, made itself felt in 1871. To the height of two storeys the walls of this hall might be of brick; above that, and a third of the entire height, the structure should be continued in ornamental iron framework glazed, and in part relieved by coloured glass, the whole length being covered in with a glazed arched roof, after the style of Paxton's transept of 1851, now transferred to Sydenham. Each end of this building should comprise grand entrances on the ground floor, organ lofts on the upper floor, and the glazed part should be of rich design in stained glass, embracing the dial-plate of a monster electric clock. Galleries should run round this hall, which on the north should give access to the picture galleries. In the centre should be arranged the basin of a fountain, that on the occasion of state ceremonials could be covered in, to form a dais. The grand hall should be devoted to the display of statuary in connection with artistically arranged groups of tropical and other plants, banners and armorial shields of nations, provinces, and trades; on the walls and from the roof of the galleries should be displayed pendent specimens of tapestries, carpets, wall decorations, papering, etc.; and in gallery cases, shawls, lace, engraved ivory, metal-work and precious stones, designs of porcelain, and other objects shown as art productions. The centre of this hall should be artistically arranged with the more imposing groups of statuary, organs or other large musical instruments, trophies of science, art, and manufactures, connected with the special series of objects belonging to the year's programme. Such a hall would form an imposing and attractive feature to the mass of the public, and during the off season it might be utilised as a winter garden.

PAPER AND CARDBOARD MAKING.—VI.

BY GEORGE TINDALL.

MILLBOARDS, CARDBOARDS, ETC.

ALTHOUGH the use of the watermark as a trade mark is now almost entirely abandoned, its value as a means of preventing forgery and as a safeguard for bank-notes, bills, cheques, etc., is very great, and its use has latterly been much developed by the invention of a means by which gradations of light and shade can be given to the paper, instead of the system of simple lines formed by wires, formerly used. Exemplifications of this process may be seen in the Bank of England notes and in postage and receipt stamps, every one of which has an elaborate watermark in addition to the very intricate designs printed on the surface, so that in order to counterfeit any of these, it would be necessary to have paper specially made for the purpose, in addition to the trouble of engraving and printing. These effects are produced from an engraving on copper or steel, similar to one prepared for printing, either by taking an electrotype which is affixed to the surface of the wire gauze forming the mould, or by using the engraving as a die, and by great pressure with a steam-hammer or otherwise, taking an impression from a thin sheet of brass, such portions as enter the lines engraved on the design being transferred to the mould, or the die is used to give the impression direct to the fine wire gauze of the mould; but in the latter case the mould must be most carefully used, as the design is soon defaced. In this way the most intricate designs may be permanently introduced into the texture of the paper, as well as the delicate effects of light and shade forming a landscape or a portrait, and at the cost of a few pounds for moulds or a dandy-roll, the exclusive use of a paper may be secured to an individual or a corporation, with an autograph, crest, or other design suitable for their use.

Waterlined brief papers are still largely made by hand, and used for legal purposes. The lines are formed by the introduction into the mould of plain wires across a wove surface, and consist of a margin line and thirty-six or forty parallel lines commencing at the margin line. A great variety of machine-made papers with the surface either lined by watermarks, or covered with designs formed in the same way, by means of special dandy-rolls, are now imported into this country from the Continent and largely used for correspondence and other purposes, whilst a small quantity is also made in England; but the use of these papers is still very limited, whilst the use of specially watermarked papers for commercial purposes is very largely increasing.

Watermarks have at various times been valuable adjuncts in the detection of crimes in courts of law; while, on the contrary, the careful study and use of watermarks enabled the celebrated forger, Ireland, for years to fabricate and pass off as genuine emanations from the pen of Shakespeare, a very large quantity of manuscripts which, at the time, deceived many of the ablest critics of the day. In a pamphlet which he afterwards published, Ireland says that he purchased the fly-leaves of old books, and being at first wholly ignorant of the watermarks used in the reign of Elizabeth, he was careful to produce his manuscripts on such sheets as were entirely without watermark; but as the demand for his wares increased he feared that this might be noticed, and learning that a jug was a common watermark of the period at which his manuscripts were supposed to be written, he made careful search for sheets of paper with this device, and afterwards introduced a certain number of sheets with this watermark in his spurious documents. This was doubtless the mark formerly used for pott papers described in our last article (Fig. 3, page 161).

Having now fully described the process of paper-making, we proceed to the manufacture of boards, of which there are two very different and distinct kinds—millboards and paste or card boards. Milled or millboards were, up to a very recent period, used exclusively for bookbinding purposes, but the inquiring and inventive spirit of the past twenty years has found almost innumerable uses for this very useful article, the chief one being box-making for drapers, milliners, and a host of other trades; they are also largely used for machine packing, and even for the inner soles of shoes. This increased use, of course, requires an increased supply, and whereas formerly millboards were made of old tarred rope and such materials as were used for strong brown papers, now hundreds of tons made almost entirely of straw are imported into England from the Continent, whilst large quantities are made here from very inferior materials, such as flax and jute waste. Hopbine has also been successfully tried for this purpose. In the making of these boards, the process, as far as the formation of the waterleaf, is precisely the same as that described in making paper by hand; but instead of placing a felt between each sheet of paper, as many sheets of waterleaf as are required for the thickness of the board to be made are placed one upon the other, and then a felt is placed upon the whole. Then another board is begun, and the same process is continued. When these are pressed the sheets become one homogeneous board, and they are afterwards treated like hand-made papers, being again pressed without felts, and then hung up in lofts to dry. Some of these boards have a beautifully-polished surface given to them by friction glazing; this is performed by a smooth piece of agate fixed in a framework, and having a regular motion given by suitable machinery; by this means a surface of about two inches is glazed by burnishing at once, and successive portions

of the board are brought under the action of the tool until the board is completed and has a surface like a plate of glass. A considerable number of very thin boards, and especially straw boards, are now made at machine like ordinary thick papers, while some boards for engine packing are made nearly an inch in thickness.

Pasteboards and cardboards although sometimes made as thick as ordinary millboards, are produced in a very different manner. In this case the various sheets of which the board is composed are made at machine in the ordinary way, and consist of a middle which for pasteboards is of inferior quality, and two outside sheets which are pasted on to the two sides of the middle, and being pressed a firm thick sheet is the result, the surface being, of course, of the finer quality of paper used for that purpose. If a very thick board is desired, two or more middles may be pasted together and then covered, whilst middles and outsides of various thicknesses may be used, and thus any weight of board may be obtained. For white pasteboards a very white or light grey middle is used, made of materials somewhat inferior to those used for fine printings, the principal requisites for a good middle being evenness of texture (as lumps show up after pasting through the covering) and colour, if for white boards; bulk is also an important consideration, as, of course, the thickness of the board depends most on the middle, and any attempt to load a middle by the addition of mineral matters to some extent defeats itself, as a heavier middle is required to secure the thickness of the board. For coloured boards such as are used for railway tickets, bonnet-boards, etc., a very common brown or grey middle is used, its quality being hidden by the coloured surface-paper. Cardboards are made in the same way, but being a better description of board the middle is usually of as good a quality of paper as the coverings, and after making they are pressed between heated zinc plates in the same way as fine papers are treated for plate glazing; this gives them a fine polished surface, as well as making the board firmer and harder. A fine, thin cardboard called ivory is made from two or more sheets of fine paper pasted together and rolled until a beautiful hard, smooth surface is produced. This is used for visiting and address cards, and for fine printing. Many cardboards are also surface-stained or enamelled by coating the card with a white or coloured composition and rolling until a good surface is obtained, as in the case of enamelling; a beautiful, smooth, and shining surface is the result of continued rolling. These operations are not usually conducted at the paper mill, the business of cardboard and pasteboard making being separate from that of paper-making, and oftener carried on in towns, while paper-mills are usually situated at some distance from large towns—except mills where coarse papers are made—on account of clear water being a very great desideratum in the production of fine papers.

Besides the important branches of millboard and cardboard making, some other applications of the paper manufacture are worthy of our attention, and of these we will notice the manufacture of articles of clothing and furniture. For many years past the use of collars, fronts, and other articles of wearing apparel made either entirely of paper or of paper in connection with linen fabric, has been steadily increasing, until this has become an important branch of the manufacturing industry of this and other countries, particularly of America, and a great number of persons are employed in this branch of commerce. In China, Japan, and some other countries, the use of paper for handkerchiefs, coverings for the head, and other articles of dress, has been known for many years; indeed, scarcely any substance is capable of being applied to so many purposes or of being made up into such a variety of useful and ornamental articles as paper. It can easily be made waterproof, and so form a shelter from rain as well as the heat of the sun; when in the shape of pulp it can be moulded to any required form, and it dries hard and firm so that it can be used for furniture, and even for building houses, and in this state it is almost fire-proof. Excellent window blinds printed in a great variety of patterns are now made from it; indeed, the uses to which it is applied are almost numberless, for it has been proposed to use it as an armour for ships in lieu of steel plates, under the belief that it would be a greater safeguard than steel and iron, whilst it would certainly be very much lighter, and so would not affect the sea-going qualities of vessels to which it was applied. After this we can easily believe that houses may be roofed or even built with it; that, in fact, there is no limit to the purposes for which it may be used. In the manufacture of furniture and wearing apparel, however, the processes are widely different; for the former, the pulp must be manipulated, whilst for the latter, the perfect sheet of paper made in the usual way is taken and treated by the makers of these articles.

Simple paper collars, etc., are made from a sheet of stout paper which is first passed between rollers to give it a surface, or is glazed in the usual way between metal plates. It is then placed in a press, and at one simple operation the collar is cut out clean by the descent of a punch or die, which at the same time impresses any pattern that may be required, and the collars are then folded and packed in dozens in neat round boxes which are likewise made of paper and pasteboard or millboard. Collars made of paper only are now, however, almost entirely superseded by linen-faced fabrics; in this case the sheet of stout paper is covered on one side with a roll of thin fine linen in the same way as the middle of a pasteboard is covered with the fine outside sheet, and by pressing and rolling the linen is incorporated with the paper and a fine glazed surface is obtained. The collars are cut out in the way just described, the products being stronger and finer, and very closely resembling fine linen. Fronts, wristbands, etc., are made in the same way, a great number and variety of dies being required for the various sizes and patterns now in use; and in some cases, where an elaborate pattern is stamped upon the article, this is done after the required shape has been cut by a punch by placing it between two plates, on one of which the required pattern has been engraved, and the other cast or moulded from it; these plates are then passed between a pair of rollers under considerable pressure, and by this means the paper is forced into the sunk spaces of the engraved plate, and stands out in bold relief when taken from it. The cuttings from the sheets, which are necessarily somewhat large, are returned to the paper-maker for re-manufacture; in many cases they are worth half their cost for this purpose, and are eagerly sought after, as are also the cuttings made in the manufacture of envelopes, and the shavings from book edges and other cut papers; when these shavings are clean they may be readily converted into pulp, and lose but little in the process.

The use of paper in covering the walls of rooms, etc., has now almost entirely superseded the old method of whitewashing or painting, and has been extended to the humblest dwellings in the land; for this purpose, also, the paper is made in the usual way, but in a continuous sheet about twenty-two inches wide, known as "long elephant." The staining or printing of the pattern is rapidly accomplished by very beautiful and simple machinery, the several colours being laid on at one operation, except in the case of very fine paper-hangings, for which the old process of block-printing by hand is still used; the papers are then cut in lengths of twelve yards, and rolled up in pieces for sale; and so rapid and cheap is the operation that a piece of paper-hanging twelve yards long, with a design beautifully printed in several colours, may be bought for a few pence.

For window blinds a broad and very strong sheet of continuous paper is used, and this is first passed through a bath of very strong size before the design is printed; afterwards it may be varnished, and in this state the surface may be washed if care is used, otherwise it can only be worn until it is dirty.

For ordinary furniture a very different method of manufacture is followed: the pulp is prepared as for paper, and consists for the most part of waste papers broken up in the engine, and run into drainers, as described in the early portion of these papers. This half stuff, as it may be called, is then taken and moulded into the required form, and after drying is varnished and polished. Articles made in this way are termed *papier maché*, and very light and durable tables, chairs, trays, and numberless other articles of furniture are produced at very small cost, the principal objection being that this substance has not the same power of retaining a firm hold of nails, screws, etc., which is possessed by wood, so that for articles requiring hinges or other similar arrangements it is not so suitable, but it may be turned in a lathe or moulded to any shape in the condition of pulp, so that it is very suitable for articles made in one piece only; it is also susceptible of a considerable amount of ornamentation by inlaying with mother-of-pearl and other substances, which is easily done when the article is in the damp soft state.

We have thus indicated some of the various *extensions*, so to speak, of the paper manufacture, though nearly all of them form separate and distinct branches of commerce, and some of them

will, no doubt, receive separate and full treatment in the pages of THE TECHNICAL EDUCATOR. Perhaps no kind of manufacture has had so large an extension in various directions as this, and perhaps no other has so largely taxed the ingenuity of its followers to supply it with the materials for its extension. Made originally from the refuse and waste of other industries, the whole surface of the globe is now ransacked for fresh fibres suitable for direct use in the manufacture of paper. Large sums have been offered as a reward for the discovery of such fibres, and the attention of many intelligent men in our colonies and elsewhere is now attracted to this subject, so that we may fairly hope that as the use of paper increases we shall be at no loss to supply the demand. The importance of this industry to every branch of art and science and to everything that tends to the elevation of mankind is incalculable, and anything calculated to facilitate or to improve it is a matter of more than national importance.

CIVIL ENGINEERING.—XVI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

HARBOURS.

OUR attention in previous chapters has been directed to those *exterior* appliances by which engineers have been enabled to protect certain parts of the coast against the violence of the sea, and to afford shelter to vessels when within their influence. We have now to speak of the harbours themselves.

And first in importance amongst the various matters which arise in connection with this subject, is the *depth* of water obtainable at the lowest point of the tide; because a mere *tidal* harbour—that is, a harbour only accessible to vessels at certain periods before and after low tide—is, after all, of only a limited value. There are not many positions on our coasts, whether sheltered by nature or art, which possess naturally a depth of water sufficient to float large vessels at all times of the tide. Indeed, some are mere mud-banks when the tide is out, exhaling poisonous effluvia. Now much of this evil is remediable.

Before, however, we point out what are the means usually adopted for obtaining and maintaining a proper depth of water in a harbour, let us see whence the causes of the evil arise. Briefly, they arise from two sources, the effects of the sea and the effects of the land-water. The same action and force which forms sand-banks, produces bars at the mouths of rivers, and throws up pebble ridges, as at Weymouth and Westward Ho, will throw mud, sand, beach, and boulders into a harbour, and if not prevented, sooner or later render it useless. When in 1774 Smeaton was requested to report upon the state of Ramsgate Harbour, and the cause of, and the remedy for, its choked condition, he found it to contain 268,700 cubic yards of silt, which was still being deposited at the rate of one inch every five weeks. The whole of this mass had been brought into the harbour by successive tides. The water upon this part of the coast is highly charged with a mixture of mud and very fine sand whenever agitated by the wind, and this silty water, finding repose in the harbour, deposits the heavy matter held in suspension, the water alone being taken back by the receding tide. This, which occurs at Ramsgate, will occur more or less at every harbour in which the enclosed water finds almost absolute repose; and the smaller the harbour, the greater its tendency to become silted up, because the back-flow of water at ebb tide is insufficient to carry back the deposited matter. This fruitful source of mischief to a harbour was almost unknown to the ancients, because the Phœnicians, the Greeks, the Romans, indeed all the old maritime nations, inhabited countries whose ports and harbours were situated on an almost tideless sea; hence we are left without record as to the plans which may have been adopted by them for remedying the evil if it existed.

Another fruitful source of mischief to a harbour is the earthy matter brought down by freshets from the interior, in the case of a river finding its way to the sea through a harbour. This earthy matter which, held in suspension, might have been carried completely out to sea if it had had an unopposed course, will generally meet with a check at the flow of the tide, and the water being thus brought to a stand-still, the same result will follow as that already indicated, the suspended matter becoming deposited in the harbour. An instance of this kind occurred at Aberdeen previous to the improvement of the harbour by Smeaton. The river Dee, which admitted the tide to flow upwards about two miles, and to spread itself over some very flat ground, did not acquire sufficient strength to carry out all the deposits that were borne down from the land in the interior through which the river flows. The tide, meeting the fresh water, occasioned the sand, stones, and mud to be deposited, and at last a bar was formed, which almost obstructed the entrance for large vessels. Smeaton discovered the cause of the deposit, and finding the river spread over a space upwards of 500 yards in breadth, he decided upon confining it within a narrower channel, and it was for this purpose that he constructed the North Pier.

This course, which proved successful in the case of Aberdeen, could not, however, be adopted in all instances; and indeed in that particular locality the old harbour, which was nothing more than the improved mouth of the river Dee, was found insufficient for the necessary accommodation, and was subsequently abandoned for artificial wet docks. Every separate locality will inevitably require its own special treatment, and hence no absolute rule can be laid down for the best method of removing deposit from a harbour, and of keeping it free. We may, however, be guided by general principles, and a careful study of the works of Smeaton, Telford, Rennie, and some of the French engineers will be the best guide to the arrangements which have proved successful in the majority of instances. It will generally be found the most efficient, and at the same time the most economical plan, to allow Nature herself to provide the remedy, assisted by a skilful application of art. If *water* has been the means of introducing the deposit, let *water* remove it. If the mud came from the land, brought down by the even flow of the river or stream, endeavour to arrest the even character of the flow, and make it intermittent, employing the pent-up water at certain periods, so that its increased flow at these times may scour the harbour, and carry the deposit far out to sea.

Probably no country has been so successful in the improvement of their harbours by the adoption of sluices for scouring them as the French. We might conduct our readers round the greater part of the sea-board of France, and show them the numerous costly, ingenious, and successful contrivances adopted by their engineers for washing away the silt from the bottom of their harbours. A few instances will, however, serve to illustrate their arrangements.

Dunkerque, or Dunkirk, presented one of the earliest and perhaps one of the finest specimens of marine engineering in France. So far back as 1689 contrivances for deepening the port and keeping it clean were adopted by M. Clément, one of the most celebrated civil engineers of his day. The harbour was provided with no less than five independent sluices, which could be used either singly or collectively. The principal sluice was at the end of the canal of Bergues. It was 26 feet in width, fitted with a double pair of gates. One of these gates supported the waters of the canal, the other those of the sea at high water. The land-water was retained by the upper gates until the period of low tide, and the scouring effect of the waters which were then discharged was felt to the end of the jetties, a distance of 3,500 yards. By means of this sluice, combined with a second 15 feet wide at the mouth of the canal of Moère, and a third at the canal of Furnes, the port was cleaned and scoured out to the depth of 15 feet.

There was, however, a sluice larger than either of the above constructed by Vauban in 1684. This was 42 feet wide, and the gates supported a weight of water 20 feet high. The foundations of the sluice were laid on a moving sand, into which were driven eight rows of piles. These were connected by as many pairs of binding pieces, between which were driven a double row of sheet piles, the joints of one row covering the joints of the other. Between the heads of the piles a foundation of brick was laid, which was brought up level with the tops of the binding pieces. Between the several rows of sheet piling were laid cross timbers, which extended throughout the whole width of the foundations which were to be occupied by the sluice. The spaces betweeen the timbers were filled in with masonry, and the whole brought to a level. A floor of oak plank was then laid over, pinned, and securely caulked at the joints. Other cross timbers were laid on this floor, and altogether an unnecessary quantity of wood seems to have been employed. The water for sluicing was allowed to flow out through aqueducts left in the masonry of the side-walls. These were 3 feet wide internally, and arched with stone, being lined throughout with hard stone to resist the friction of the water when rushing out. The aqueducts were

closed by paddles 3 feet 6 inches wide, working in iron grooves introduced into the masonry. The paddles, which had to sustain a considerable pressure of water, were raised and lowered by means of a nut turned by levers which threaded upon a screw cut in the iron rod attached to them.

The port of Cherbourg is another instance of a harbour whose depth is maintained to 18 feet by successful sluicing. The river Yvettes is let into the inner harbour by the opening of the gates of a large sluice, and the accumulated mud is ploughed up and carried out to sea.

It is by no means necessary that a natural supply of water for sluicing purposes should exist. When such is the case, it becomes of course the more economical; but frequently there exists not even a small stream whose water can be rendered available by accumulation. At Boulogne the small stream, the Lianne, which would be entirely inadequate in its natural condition to keep the harbour clean, is allowed to flow into a large basin whose level is considerably above the water of the harbour at low tide, and there it accumulates during the period from one tide to another, and thus acquires a volume and force of discharge amply sufficient for scouring purposes.

In other cases, as at Tréport and at Ramsgate, the water for scouring is obtained directly and exclusively from the sea. An artificial basin is formed, communicating by gates with the harbour. The rising tide opens these gates and fills the basin to its own level; the gates close as the tide recedes by the superior weight of water upon the inside, and are retained there until the tide has fallen sufficiently low, when the sluice-gates are opened and the scour follows. This is one of the most efficient methods for keeping a tidal harbour free of the deposits which tend to form therein.

Another method, less efficient and more expensive, because the cost is continuous, is by dredging. This system is adopted in very many localities, and amongst them at Hull. The waters of the Humber flow over vast mud-banks, and contain earthy matter in suspension in immense quantities. This is deposited to a very great extent in the docks, it being calculated to amount annually to 36,000 tons in the Humber Dock alone, which contains an area of a little more than 7 acres, being 914 feet long, and 342 feet broad. The dredge may be generally described as an iron bucket with a sharp-edged, broad, projecting lip, the bucket being perforated at the bottom and for some extent up the sides to allow the water to flow out. The bucket is lowered to the bottom, and drawn along the soil sideways, and is then brought to the surface filled with mud; the water which comes up with it flows away through the perforations. The mud which remains behind is then discharged into a lighter. The steam-dredging machine is an arrangement for carrying out the principle upon an enlarged and improved scale. It consists of a series of buckets similar to those already described, fixed at intervals upon the outer side of an endless chain consisting of long iron links, the chain passing over a square tumbler worked by steam-power. The buckets descend into the water upon one side of the chain, and touch the bottom mouth foremost, scooping up a quantity of mud, and rising upon the other side of the chain full of soil, which falls out of the buckets as they pass over the tumbler, and is caught by a lighter moored below. The machine employed in the Humber Dock is placed on a flat-bottomed vessel which draws 5 feet of water. It is worked by a steam-engine of 6-horse power. By means of a bell-crank motion is given to cog-wheels. On the axis of the upper one is the square tumbler, with a corresponding one at the lower end of the bucket-frame. There are twenty-nine iron buckets on the chain, and the exact depth to which they descend is regulated by a crab and tackling, from which the lower tumbler-wheel depends. About from forty-five to sixty tons of mud can be raised per hour; this is deposited in flat-bottomed mud-boats drawing 4 feet of water, and capable of carrying forty tons of mud. Care must be taken to convey away the mud which has been dredged to a sufficient distance out to sea, in order that the action of the tide shall not bring it back to the harbour.

In order that a harbour may be of use to the shipping frequenting it, it requires not only to be sheltered from the violence of the sea, and to possess a sufficient depth of water for vessels to ride securely, but it must have good anchorage. The natural character of the ground may form a sufficiently good hold for ships' anchors, in which case it may not be necessary to lay down moorings for ordinary purposes. But to facilitate the departure or movement of vessels, buoyed moorings are extremely valuable. Such a mooring consists usually of a screw forced into the ground, having a moving or swivel head, as shown in Fig. 37.

The harder the ground into which the screw has to be forced, the heavier and stronger the screw is required to be. A screw weighing 9 cwt. will form an efficient mooring. For a mooring-chain $1\frac{1}{4}$ inch diameter, the diameter of the disc or screw should be 4 feet, and the weight about 11 cwt. The character of a screw for mooring purposes varies according to the opinion of the engineer; some prefer a broad disc with few turns, whilst others consider a greater number of turns and a narrower disc preferable. The value of screws for holding purposes is very great. In 1851 an experiment was tried on the Godwin Sands with a hollow pile six inches diameter, fitted with a screw at the lower extremity. This was screwed down with ease to a depth of more than fifty feet, passing through a fine, compact sand. They have been employed in a variety of ways with great success, some of which we shall have occasion to refer to again more minutely.

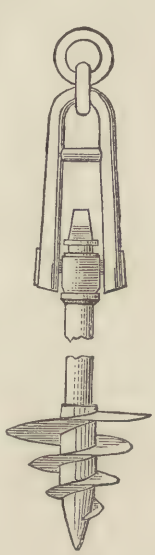


Fig. 37.

The head of the pile used for mooring purposes is fitted, as we have said, with a swivel. To this is attached one end of a chain, the other end being fastened to an iron ring fixed to a buoy, and having sufficient length to reach to the surface of the water at the highest point of the tide, with a small amount of slack to spare. The buoy must have sufficient power of flotation to support easily the weight of the chain. Attached to the upper side of the buoy is a large ring, and to this the cables of vessels requiring to be moored are fastened. By this arrangement the vessel is very readily released, although whilst so attached it is more securely fastened than if it were riding at its own anchor. In rivers greatly frequented by shipping, as the Thames, it becomes necessary to lay down the buoys for the use of vessels in such positions as that the channel shall be kept free for passing ships. In order to render such buoys of use, it is necessary to compel vessels to employ them.

There are other accessories which are necessary to render a harbour useful to shipping. There should exist stores of all such materials as may be required for refitting disabled vessels—as, for instance, of sails, cordage, spars, anchors, and so on; also provisions and fresh water, and the means for readily gaining access to these stores. With respect to jetties, piers, wharves, etc., we have already directed attention to them.

The subjects treated of in these papers do not include military engineering matters, and it is therefore not our intention to enlarge upon the desirability of protecting the approaches to a harbour from the possible attacks of an enemy. It is natural to infer that in time of war the cruisers of an enemy will direct their attention to those points of coast in which their opponents' vessels would be collected, and hence such points require special defences. A very few guns of large calibre advantageously posted will prove of immense benefit in protecting the vessels which have sought refuge within the harbour; but a more efficient plan is to alter the bearings by which safe access is gained to the harbour, and thus to throw the enemy's ships upon rocks. This system, however, has its disadvantages, inasmuch as friendly ships may meet with the disaster intended for the enemy. Probably the most efficient plan for the military protection of a harbour is by the modern appliance of torpedoes. These most destructive implements of war, against whose power the strongest iron-clad is as helpless as the smallest boat, can be employed at will against any particular vessel it is desired to operate upon, by means of electricity, the wires conveying the current being laid under water to the shore, where they are placed under the charge of an operator, who by the simple pressure of a key completes the circuit by which the torpedo is instantaneously exploded.

Our next chapter will take up the subject of lighthouses, those most indispensable adjuncts to the entrances to harbours, and all exposed points of a coast.

MINING AND QUARRYING.—XX.

BY GEORGE GLADSTONE, F.C.S.

COPPER (*continued*).

SMELTING—LOCALITY OF WORKS—SWANSEA PROCESS—MODIFICATIONS—PRECIPITATED COPPER—FOREIGN PLANS—CHILIAN REGULUS.

SWANSEA and its immediate neighbourhood, Llanelly, Neath, and Pembrey, is the great centre of the copper-smelters. There are also some works at St. Helen's in Lancashire; and copper forms a subsidiary product of those vitriol works at Newcastle and elsewhere, in which pyrites are used as the source of sulphur. Reference to these will be found in "Chemistry applied to the Arts," Article XI.

Not only are one-half of the markets of the world supplied with their copper from Swansea, but the ores are sent there from every quarter of the globe to be smelted. Except, therefore, when mention is made to the contrary, the practices about to be described may be understood to be those adopted in South Wales.

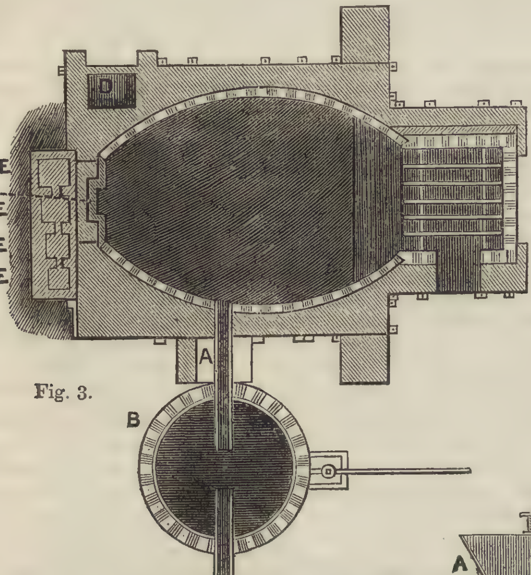


Fig. 3.

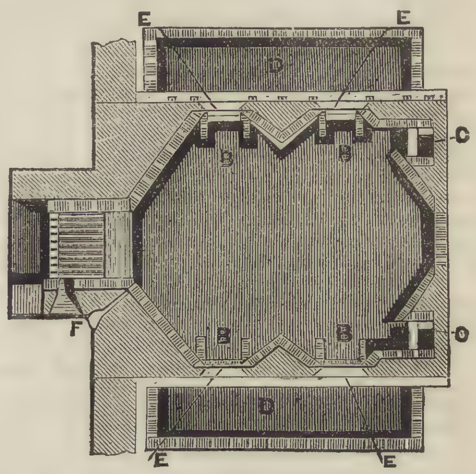
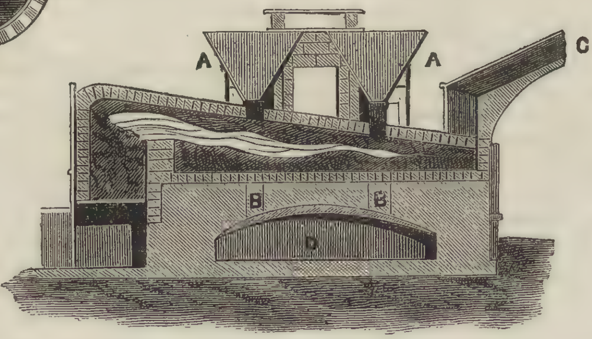


Fig. 1.

Fig. 2.



The ores have to be subjected to at least six operations in order to convert them into good copper; but sometimes as many as ten are necessary, when ores of a peculiar character, or very low per-centage, are smelted by themselves. In the large works it is customary to buy a number of different parcels of ore; low sulphides, some containing a large proportion of iron, and others much quartz or earthy matter, oxides and carbonates, and regulus, which is roasted ore, often containing 50 per cent. of metal. By a judicious admixture of these different descriptions, the number of operations, and therefore the cost of the reduction, is reduced to a minimum. How this is accomplished will be seen presently.

The first step is to calcine the ores for the purpose of driving off a portion of the sulphur with which they are combined. As the great bulk of ores consist of sulphides, this preliminary operation is always necessary; especially as the richer ores, such as the carbonates, are mostly reserved for use at a later stage. The calcination is performed in a reverberatory furnace, the ordinary form of which is shown in the accompanying diagrams, Figs. 1 and 2 representing the ground-plan and section. The charge is allowed to fall from the hoppers, A, A, upon the sole of the furnace, where it is subjected to a considerable temperature, but not sufficient to make the ore clot together; it is kept stirred at intervals by the furnace-men, who are provided with rabbles which are inserted through the working doors, E, E, so that all of it may be brought equally under the influence of the fire. The flues, C, are at the opposite end of the furnace. When the calcination is complete, the coverings to the openings, B, B, leading to the vaulted chamber, D, below, which are immediately inside the working doors, are removed, and the ore is raked through. The fuel used is coal, and the draught is so regulated through the furnace-bars, and by the air-passage, that the flame shall extend over the whole inside area. It is almost superfluous to say that in this and all subsequent operations the fuel should be as free from sulphur as possible, the principal object of the calcination being to drive off that element. From nine to twelve hours are necessary in this case, the time being somewhat dependent upon the character of the ore. During this process about one-half of the sulphur will have been expelled, and the copper thus set free will have been converted into an oxide; while the greater part of the arsenic which the crude ores may have contained will have been volatilised.

The principal object of the second operation is to separate the earthy matter and the iron, and to effect this the calcined ore is again heated in a reverberatory furnace of a somewhat different form, and at a higher temperature than before. The usual shape is shown in Fig. 3. The sole inclines downwards towards the pipe A, which leads to the tank B. The working door is at C, and D is the chimney. The charge, which consists of some fusible cupreous slag from some subsequent operations, in addition to the calcined ore, is passed in through a hopper, as in the former case, and is there left for three or four hours, the pipe A and the working door being both kept closed all the time. The charge soon melts, and the iron enters into combination with the flux, forming a silicate of that metal; during this transformation, the sulphur liberated from the iron is converted into sulphurous acid, which, in its efforts to escape, keeps the molten mass sufficiently agitated. Sometimes fluor-spar is added to the flux, which facilitates the fusion, and aids also in discharging any arsenic which may remain from the first calcination. The heat is then got up still higher, and presently the tap-hole is opened, and the fused matt which has collected in the lower part of the hearth opposite A, is drawn off through the pipe into the cistern. The viscid slag which overlies it is then drawn out with a rake through the working door, C, and is allowed to collect in the four receptacles, E, E, E, E; the two central ones are first filled, and the other two only take the overflow; the

consequence of this is, that almost all the metal which has remained mixed with the slag (being of greater specific gravity than the rest) sinks to the bottom of the two central compartments, while the others contain so little as to be rarely worth recovering. When the contents are cold, the scoriæ are broken to pieces, and those portions which are worth melting again are added to the next charge. The tank B contains cold water, and the hot matt or regulus on falling into it becomes granulated so as to be ready for the next operation. It is now termed "coarse metal." It consists of a mixture of copper and iron, both in the state of sulphide, with little or no earthy matter, the latter having been entirely removed along with the oxygen and a part of the iron in making the silicate. A fair average sample will contain about 33 per cent. of copper, a similar proportion of iron, and about 30 per cent. of sulphur.

The next two steps of the process bear a great resemblance to those already described. The coarse metal is calcined in a furnace similar to the first, for the purpose of expelling more of the sulphur and reproducing the oxide; the 30 per cent. of sulphur being then reduced to about 17 per cent., and the loss replaced by so much oxygen. This product is then fused again to separate the iron, and leave as pure a sulphide as possible. The result of this is "blue metal," as it is called, consisting usually of about 57 per cent. of copper, 16 of iron, and 23 of sulphur. If, from any cause, such as the poverty or special character of the ores dealt with, or any faults in the manufacture, such a metal should not be attained at this stage, the processes already described are repeated until a satisfactory result shall have been arrived at; this will involve an addition of either two or four operations. On the other hand, if a large proportion of the red oxide or carbonate of copper is added to the calcined coarse metal before being melted again, a superior product will be obtained, called for distinction "white metal," which will contain scarcely any iron, and will almost equal a pure disulphide of copper.

We then come to what shall be termed the fifth stage—though in practice it may be the seventh or ninth—the making of "blister copper." The object of this operation is the expulsion of all the iron and sulphur remaining in the blue metal. The furnace is only raised to a moderate heat at first, and the air-passages are left open so that there may be a sufficient supply of oxygen to effect the decomposition of the sulphides and the formation of sulphurous acid. So long as this is being formed, the whole of the contents of the furnace are kept in a sufficient state of agitation to render rabbling unnecessary; but as soon as this part of the reaction is complete, the doors must be closed, and the furnace brought up to a higher temperature and kept at its full heat for about twenty-four hours. The remaining part of the sulphur is thus expelled, and the oxides which have been formed during the previous part of the roasting are converted into silicates, which separate from the metal as a slag. The latter is then skimmed off, and the copper is allowed to run through the tap-hole into moulds. The blister copper thus obtained should contain from 93 to 96 per cent. of pure metal, the principal other ingredient being oxygen. The slag which has been separated from it will be found to contain a good deal of oxide of copper, which is recovered in some of the earlier operations.

Only one more process is now required to convert the blister copper into an article fit for the market. This is the refining. A large reverberatory furnace of the ordinary form is employed, well arranged for maintaining a high temperature, which is charged with six to ten tons of blister copper at a time. The heat to which it is raised causes the metal to melt in about six hours, and the temperature is still increased so that the oxygen may become combined with the silica, and form scoriæ, which will float upon the surface. After an exposure to this intense heat for about twenty hours, the furnace-man rakes off the small quantity of scoriæ that is overlying the metal, and then draws a sample of the copper in a ladle, which is tested as soon as cold. From the appearance of the fracture the refiner judges how to treat the contents of the furnace. Some charcoal or anthracite dust is thrown upon the surface of the molten metal to prevent it from absorbing any oxygen from the air which passes through the furnace, and the remainder of that gas which may still remain in combination is dispelled by poling, a billet of green wood being employed for the same purpose as has already been described in treating of the refining of tin. During the poling a small sample of copper is withdrawn and tested from time to time, because the quality is spoilt if it be overpoled, by the formation of a carbide of copper. The right point having been arrived at, the pole is withdrawn, the scum which has accumulated on the surface is skimmed off, and the metal is then lifted out in ladles lined with clay, and poured into the ingot moulds to cool. The cooling process is expedited by inverting the moulds over a bath of cold water, and letting the ingot of copper fall in, as soon as it is sufficiently solidified. The action of the water also imparts to the surface of the metal a slight bloom, which is valued in some markets.

Various processes have been invented at different times for simplifying those already described; but as a rule they have not maintained their ground against the old-established plan.

The principal novelty in one of these which was practised for some time, consisted in the removal of the arsenic, tin, antimony, and other metallic impurities, by converting them into soluble salts by fusing the calcined ores with the addition of some soda ash. The contents of the furnace are subsequently put into tanks of water, when the foreign matters dissolve out, leaving the sulphide of copper in a finely-divided state, which is then ready for the second calcination.

Another modification depended upon the conversion of the sulphide into a sulphate, which is readily soluble in water, so that the metallic salt could be dissolved out, leaving the whole of the earthy matter behind. From this solution the copper is easily separated by the agency of iron, the latter taking the place of the former, and becoming converted into a sulphate, while the copper is deposited in a metallic state. It is necessary, however, to brush the copper off the sheets of iron from time to time, or the deposit would soon become so thick as to check any further action. The copper then only requires refining. The result is a very pure and highly malleable metal; but the necessity of grinding the ore in the first instance preparatory to converting it into a sulphate, and the loss of iron in precipitating the copper, have prevented its adoption on a large scale.

The greater affinity of the sulphuric acid for the iron over the copper, led to the adoption of this reaction at the works of the Great Parys Mine in Anglesea. The water from the dressing floors, as well as that pumped up out of the mine, became so highly charged with this copper salt that it was found well worth while to carry it into large reservoirs for the purpose of precipitating the metal. Iron plates were immersed in the liquid, and the copper deposited upon them was brushed off daily, until the iron was so far eaten away that fresh plates had to be substituted for the old ones.

In Germany, Sweden, Russia, and France, where oxides and carbonates of copper are more common, the smelting process is often simpler, and blast-furnaces are frequently used instead of those made on the reverberatory principle, which are alone adopted in England. As the foreign plans are not equally applicable to the prevailing character of the English ores, it will be unnecessary to go into these in detail.

In Chili, and some other foreign parts, the ore is very frequently converted into regulus on the spot, and sent in this condition to Swansea, to undergo the final operations. The carriage of a considerable per-centage of useless gangue is thereby saved, and the ships which bring the regulus to this country take out the coals which are to be used in the reduction works at the mines.

BUILDERS' QUANTITIES AND MEASUREMENTS.—IX.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY.

ALTHOUGH the joiner works in a similar material to that used by the carpenter, yet the character of his work is very different, requiring another class of tools, which must be used with greater care, and more finish is put upon the material. And whereas the carpenter's work is mostly executed out of doors, that of the joiner is always done in a workshop or close shed, so as to be unaffected by weather or change of temperature.

The work of the joiner consists in the framing and hanging of doors, shutters, and sashes, laying floor boards on the joists fixed by the carpenter, framing and fixing wooden stairs, handrails, and balusters; putting skirtings and dados round the

rooms, framing and fixing wainscoting or other framed work, and all the internal fittings and decorations which have to be made of deal, oak, mahogany, or any other wood.

The joiner has also to fix the ironmongery, as locks, hinges, bolts, knobs, screws, latches, etc., upon his work, and for this reason the ironmonger is always taken with the joiner in measuring, the several articles of that trade being numbered as each part of the joiner's work is measured, and afterwards brought into bill at the end of the joiner's bill as "ironmongery and fixing."

It is usual in measuring joiners' work to consider that the materials and labour are taken together and charged at one price; but there are cases when the materials are found by one person and the labour by another, in which case the work is taken as "labour only and fixing," or as "labour, nails, and fixing," which latter includes glue, nails, and everything except the raw material. In measuring joiners' work no allowance is made for tenons, the superficial area of any framing being exactly measured, and its character and thickness described fully. If the work is less than $4\frac{1}{2}$ inches wide, it is usual to take it by running measure, describing thickness, width, and labour upon it. Small or ornamental works, that cannot be measured, are numbered and described.

In measuring the floor of a rectangular room, take the exact superficial area, adding the area of all recesses or irregular pieces. If the sides of a recess are on the splay, the area of the piece of flooring must be taken by its greatest length, as if rectangular, or the nett measurement may be taken, and the splays measured, their length by a width of 3 inches for an addition to the superficial measurement, or else as run of cutting to splay. If the room is not rectangular, a proper allowance must be made in taking the dimensions, and all cuttings measured as above described. The space occupied by the hearths of fireplaces is not generally deducted from the measurement of the floor, unless there is a mitred border round the hearth, in which case deduct the area of the hearth, and measure the mitred border by the foot run as extra.

The material, thickness, and mode of construction of the floor must be described, whether deals, battens, or wainscot, the thickness as $\frac{3}{4}$ inch, or "three-cut," 1 inch or "two-cut," $1\frac{1}{4}$ inch, etc.; whether folding, straight-joint, with splayed or tongued headings, dowelled or tongued.

In measuring skirtings and dados first take the run of the skirting for the "grounds," describing the thickness and width, and if plugged to wall. Then take the length of the skirting, allowing for the angles, by the width, as superficial measure; describe the thickness, width, character of moulding, with backings, whether straight, raking, ramped, or circular; if scribed to stone steps, plugged, rebated to form double plinth, writhed, or otherwise. Number all mitred or tongued angles, housings, etc.

Where deal, oak, or any other wood is used in joiners' work of uniform thickness throughout, its superficial area is taken, the thickness stated, and the workmanship described, as wrought on one or both sides, framed or clamped, matched and beaded, dovetailed or keyed, ploughed and tongued, staff-beaded, ledged, etc. If the ends are mortice-clamped, take their run, and number any mitres. All bearers, fillets, slips, etc., are taken by the foot run, describing their dimensions, and if chamfered, beaded, grooved, rebated, etc.

Framed partitions formed into panels are measured nett by the superficial foot, describing the thickness, and whether square framed, moulded and square, that is, with a moulding planted on one side only of each panel, bead-butt and square, bead-flush and square, moulded or beaded on both sides. Spandril framing having a raking top-rail, is measured nett and described as such; if circular or curved on plan, describe the sweep of the curve.

All doors are measured by the superficial foot, taking the nett height and width; folding doors must have the rebate on each leaf measured in taking the width, state the thickness, and describe whether ledged or braced, giving the size of the ledges and braces, and if wrought, tongued, or beaded; if panelled, whether plain "square," that is, without mouldings to the panels, moulded on one side and square on the other, bead-flush or bead-butt and square, moulded both sides, moulded and bead-flush, or otherwise. If the moulding projects beyond the face of the rails, describe as bolection moulded. State the number of panels in each door. All hinges, bolts, locks, knobs, furniture, to be numbered and put under the head of ironmongery. In giving the thickness of doors or other framing it is usual to state the thickness of the rough wood out of which the styles and rails have been got, and not the finished thickness; thus a 2-inch door really finishes little more than $1\frac{3}{4}$ inches.

The linings to which inside doors are hung are measured superficial, taking the nett length as seen in the opening, and adding thereto four thicknesses of the linings, by the nett width. Describe the thickness, whether single or double rebated, beaded on one or both sides, framed in panels, and if circular. The grounds on the outside of the door linings are taken by the foot superficial, their nett length round the outer edge, adding twice the width thereto, by the width; state thickness, and whether beaded or otherwise worked; the labour in this case will be only on one side, the back being left rough. The architrave mouldings round the grounds are taken by the foot run, measured round the outer edge, and adding twice the width to the running dimension; describe the thickness and width. If there is a moulded cornice over the door, take its girt by its length as superficial measure, adding extra measure for the mitres.

In measuring outside or entrance doors the frames, if solid, double rebated and beaded, are taken as "cube proper doorcase," as described under "Carpenter;" the fanlight is measured separately by the foot superficial, describing its thickness and the character of its mouldings, and if circular or square headed. If the doors have circular or curved heads, measure the straight part in the usual way, and take the circular part as if square, describing it as circular.

Sash doors, having the upper panels prepared for glass, are measured in the same way as other doors, and stating whether with diminished styles. In measuring doors that are circular on plan, either the nett measure can be taken and described as circular on plan, or an allowance can be made in taking the width of one and a half for a flat sweep of $\frac{1}{4}$ inch to the foot, double for a quick sweep of $\frac{1}{2}$ inch to a foot, two and a half if a sharper sweep than the last; they can then be classed as straight doors. Also in measuring circular-headed doors, if the circular part be taken three times, or four times for elliptical or gothic, the superficial measurement can be added to that of the square-headed doors of similar character.

Wooden gates are measured by the foot superficial, describing thickness and construction, whether open bars, cross bars, chamfered, panelled, etc.; number and describe all the iron-work thereto.

Closet fronts are measured by the foot superficial, deducting the opening for the doors, and measuring them separately. If curved on plan to a flat sweep of $\frac{1}{4}$ inch rise to the foot, add one-third to the width in measuring; if a sweep of $\frac{1}{2}$ inch rise to the foot, add one half, and then they can be taken as if straight; or else take their net measure, the height by the girt, and describe the sweep. The closet tops and shelves are measured separately by the foot superficial, the architrave moulding, fillets, and pin-rails being taken by the foot run, numbering the pins. Narrow deal or mahogany skirting round the top of dwarf closets is taken by the foot run, numbering any dovetail angles.

Shop front and counter enclosures are measured by the superficial foot, taking circular parts in the way described above for closet fronts. Friezes and cradling to shop fronts are taken by the foot superficial, describing the cradling whether with ploughed and tongued blockings, and the frieze as keyed, feather-tongued joints, etc.; circular work being measured as above described.

Sliding sashes are usually measured by the foot superficial, including the cased frames, oak sills, lines, pulleys, weights, etc. Take the height from the under side of the sill to the top of the head, and the width in the clear opening with 9 inches added on. Describe the thickness of the sashes, whether single or double hung, the character of their mouldings, the sort of pulleys, lines, and weights used in hanging them; whether with oak sill, single or double sunk, weathered or throated; and state any peculiarities in the form of the window. Number the sash fastenings. If the sashes are curved on plan to a flat sweep of $\frac{1}{4}$ inch rise to the foot, measure the girt one and a half times, and multiply by the height as before; they can then be placed among the straight windows; if the sweep is $\frac{1}{2}$ inch rise to the foot, take double the girt by the height; or the nett measurements can be given and the sweep described, the items in that case being kept separate from the straight.

Casements hung to solid rebated frames are measured in the same manner as sliding sashes, including the whole of the frame in the superficial measurement, and describing the sills, frames, and casements. If circular on plan allow as before, or else take nett girt and describe. The frames may also be taken separately, and cubed as solid frames, the casements only being measured superficial.

Skylights are measured superficial, taking the length by the width, and describing as ovolo, chamfer bar, astragal, etc., and whether rectangular or irregular on plan. If hipped, take the run of the hips as extra upon the superficial measurement. Curbs in two thicknesses to circular or elliptical skylights are taken by the foot run.

Venetian frames and sashes, with solid or cased mullions, are taken separately from ordinary sashes, but measured in the same way.

In measuring window backs and elbows, take the height from the floor to the under side of the beaded capping by the length, allowing for the passings at the angles, and the capping by the foot run. Number the caps of the elbows. The soffits are taken by their superficial area, but if the ends are splayed, measure the greatest length by the width. If the work is circular, take the girt one and a half times for a flat sweep, and double for a quick curve; it can then be abstracted with the straight work; but if measured nett it must be abstracted separately.

Grounds round windows are measured by the superficial foot, the length being taken round the outer edge, the thickness and labour thereon being described. Architrave mouldings are taken by the foot run when less than 4½ inches in girt, all mitres being numbered. Large mouldings by the foot superficial, the length by the girt.

Folding shutters are measured the same way as folding doors, allowing for the rebates; the back-flaps are measured separately if there is less work upon them. Describe the thickness and number of panels in height, and how finished; number cuttings for shutter bars, as well as all ironmongery. When the shutters fit into boxings, measure the boxings and back-linings by the foot superficial, stating the thickness, and whether they are rebated, beaded, or on splay, and if the back-linings are plain or framed. Number the soffits and boxings and also the elbow caps.

Sliding shutters, hung with cords and balance-weights, are measured by the superficial foot, stating thickness and describing the number of the panels and the labour upon them, lines, pulleys, and weights. Run the grooves and the flap for covering the top of the shutters when let down.

Outside folding shutters are measured same as those for the inside, the hanging style being taken by the foot run, or else measured in with the area of the shutters.

In measuring coiled shutters, whether of wood, iron, or steel, the superficial area is taken, with an allowance of 2 inches in width, and from 9 to 12 inches in the height; this is for shutters coiled at top or bottom. If coiled horizontally, allow 6 inches in height, and 9 inches in length.

In measuring the fittings of the water-closet, take the superficial of the seat and riser, describing the mode of fixing and thickness, number the dished hole, beaded hand-hole, and all rounded corners. Run the moulded nosing to seat. Take the area of the flap and frame, describing the thickness and labour thereon. Run the skirting round seat if narrow, numbering the mitres. Angle shelves, boxes, etc., in corner of water-closets, can be numbered.

Wooden staircases are measured by the foot superficial, taking the girt of treads and risers to the flyers by the extreme length of the tread; describe the material, thickness of treads and risers, whether glued, blocked, and bracketed, the number and scantling of the carriages, and if with returned moulded nosing to the treads, if cut and mitred to string, housed to string, etc. The curtail or other kind of end to bottom step to be taken separately. If there are winders, measure the nett area of treads and risers, including the nosings; grooving and tongueing by the foot run. Number the housings, the circular ends of nosings, circular cut brackets, etc. Number the dovetailed sinkings for balusters. Take the run of each baluster, describing their thickness and workmanship. Iron balusters and newels to be taken separately in the same way. Handrails are measured by the foot run along the middle, the parts that are circular, ramped, or wreathed, being measured separately from the straight. Take the run of sinking for iron core, the number of the handrail screws, the number of scroll or other ends, moulded caps, screw nut and joint, etc.

The strings into which the treads and risers are framed, as described in Article XIX. on "Building Construction," are measured by the superficial foot, taking the length out and out by the width, describing their thickness, if framed, rebated, beaded, sunk, or moulded, cut and mitred to risers, wreathed or circular. The measurement of ramps and wreaths is to be kept separate from the straight work. All tongued angles, housings, splayed ends, etc., are to be numbered. Cuttings and ramps to wall-strings are taken by the foot run, describing whether plain, circular, moulded, rebated, or reeded.

Apron linings, fascias, etc., are to be measured by the superficial foot.

Beaded or square angle-staff plugged to external angles of rooms is measured by the foot run.

Take the run of narrow window bottoms or nosings, numbering the rounded or returned ends. Number all rounded ends to shelves, notchings, or other small cuttings.

The sashes of shop-fronts can be taken by the foot superficial when the squares are of moderate size and all of wood, the circular parts being measured separately. But when there are few or no intermediate bars, or if brass sash bars are used, they should be taken by the foot run, describing the size of each bar and its design. Angle-bars, beaded stops, guard or angle beads, are taken by the foot run when the sash is measured superficial.

Pilasters and columns, when imitated in wood, are measured by the superficial foot, the height by the girt, stating the diameter of the columns, and whether straight, diminished, or curved. The caps and bases are numbered. Grooves and flutings are taken by the foot run, describing the diameter and form of section; the stopped or turned ends to fluting are numbered.

In abstracting the joiners' work all the various thicknesses must be kept in separate columns under heads of "rough," "wrought one side," "wrought two sides." Work that is measured by the square has a separate column from that which is taken by the foot. Shutters, doors, sashes, and frames, mouldings, runs, and numbers will all have distinct columns.

In abstracting the ironmongery, form separate columns for hinges, bolts, screws, door springs, locks, knobs, fastenings, etc. keeping the different sized hinges, locks, bolts, etc., separate one from the other. The hinges are always taken in pairs, except swing centres or spring hinges, which may be taken singly. In numbering the locks a full description of the size and quality must be given, together with the kind of furniture belonging to them. Small articles, as mahogany knobs, brass hooks, shutter lifts, are taken by the dozen. Shutter bars are valued by the inch in length; espagnolette bolts for French casements are taken by the foot, describing the diameter of the rod; but if under 5 feet they must be taken as 5 feet long.

SANITARY ENGINEERING.—XVII.

DRAINAGE AND WATER-SUPPLY.

MANUFACTURE AND ARRANGEMENT OF PIPES.

In two preceding papers we have been dealing with the broad question of water-supply for country districts and metropolitan neighbourhoods; and we now go one step further in detail to consider the manufacture of the pipes, with which, when the water is laid on to the house, it is carried to the various quarters required. In all high-class work these are almost invariably of lead, manufactured for the most part as under. We give a description of what is probably one of the most powerful machines now in work at a large well-known factory in Southwark. The power is that of an hydraulic press, and the one in question was specially made and actually used in fixing the tubes of the Britannia Bridge over the Menai Straits. Above is fixed the vessel that receives the charge of from two to four cwt. of lead in a semi-fluid state, supplied from a copper connected close by. When the charge is in the receiver, the plunger of the press gradually rises and presses the lead through a mandril at the bottom of the receiver, from which it issues as one continuous pipe, the size and weight of which is varied at will by the use of different mandrils. It will be seen at once what an immense length of ordinary pipe is obtainable without joint by this

process. In practice, however, it is usual to cut the pipe off in lengths of sixty feet, for convenience of stowage and transport.

The action of some kinds of water upon lead pipes is very destructive, and the cases of lead poisoning that we hear of arise from this cause. As a general rule hard water is much less destructive than soft, as the calcareous or similar matter with which the water is charged stops corrosion at a certain point by forming an insoluble coating, which prevents further decay; while the soft water dissolves and washes away coat after coat, which it holds in solution with the worst effect, especially if the water has been in contact with the lead for some considerable time.

When the water is of this nature iron pipe properly protected from rust may be used, and we may mention, as the best preparation that has come under our notice, a solution invented by Dr. Angus Smith. It is of a bituminary nature, and if applied when the pipe is thoroughly clean it is perfectly efficacious; as pipes thus treated have been examined after fifteen years' use, and found as perfect as when first laid down.

And here we may note the great advances that have been made of late years in the manufacture of iron piping, and recommend its adoption with proper precautions in place of lead. Thirty years ago wrought-iron pipe of ordinary dimensions was not made, but now it is a very extensive branch of manufacture, especially at Birmingham. It is manufactured by passing plates of iron at welding heat through rollers specially constructed for the purpose, which at the same time produce a pipe perfectly true, and form a sound longitudinal joint. Pipes thus manufactured may be made to almost any required strength. It is not uncommon, when required for hot water or steam purposes, to have them tested up to 3,000 lb. pressure to the square inch. They are very much cheaper than lead, though not so easily fixed, for this reason, that the lead can be beaten cold to almost any required angle, and bent as necessary, whereas it is requisite for bending that iron pipe should be heated in a forge. Custom has much to do with the matter. Iron pipes are constantly used for the laying on of gas, and there is no practical reason why they should not be used in the same way for water. Though it is very rarely done *inside* the house, *outside* iron is in almost universal use. The mains of the companies are all of iron; and if an engineer is called in to lay on the water to a mansion in course of erection, or to arrange a village or town supply, he invariably uses iron pipe throughout, until the interior of the house is reached, then the plumber steps in, and lead, a far more expensive material, replaces the iron that has done the work so far.

An invention has been recently brought out, which provides effectually against the corrosive action of soft water upon lead. By a patent recently taken out by a Mr. Haines, pipe is manufactured by a process somewhat similar to that above described for lead, in which that material is provided with an inner coating of tin. It is called "Haines' Patent Lead Encased Block Tin Pipe," and the process of manufacture is so perfect that it can be bent, handled, and manipulated with the same facility as lead, than which, however, it is considerably stronger. It has been submitted to Dr. Letheby, Dr. Lankester, and other authorities of unquestioned weight, and has their distinct approval from a sanitary point of view; and we append the result of some experiments made by Mr. Kirkaldy's well-known testing apparatus on the question of strength.

In the course of July of this year (1871) Haines' half-inch pipe, weighing per yard 4·917 lb., burst with a pressure per inch of 1,859 lb. Half-inch common lead, weighing 7·130 lb., burst with 1,579 lb. Haines' two-inch, weight 16·406 lb., burst with 642 lb. per inch. Two-inch common lead, weighing 27·967 lb., burst with 498 lb. The pipe is more expensive than ordinary lead, but its extra strength enables us to use a less weight of pipe in proportion, and thus its extraordinary hygienic advantages are attainable at no greater expense than that entailed by the use of the commoner material. It should be borne in mind also, that lead should never be used when hot water is in question; the heat of water approaching the boiling-point expands the pipe beyond its power of contraction, distortion is the inevitable result, and in course of time, fracture and failure. If any further argument were wanted to show the comparative advantage of iron over lead for ordinary water-supply, the invariable use of iron pipes for all purposes connected with warming by water, of which we have given full details in some previous papers, may be taken as conclusive upon this point.

A fruitful source of inconvenience arises when lead pipes are laid under the pavement from the main to the front wall of the house, passing in many cases over the cellar under the street. In case of any repairs or alteration, it is a common accident that a small hole should be cut in the pipe with a sharp point of a labourer's pick, the pipe being still underground, and the man unconscious of the mischief he has done. The paving work being completed, the workmen leave, and the leak continues, and is only discovered when the whole of the earth above the cellar arch is saturated with water; and the brickwork of the arch being in the same condition, the damp makes its appearance on the inside, and leads to the necessary investigation. Cellars previously fit for the storing of dry goods, once thoroughly saturated in this way, are not fit for use again for the same purpose for many months.

In laying on water where the intermittent system is in use, as in the London districts, it is of great importance that the service be large enough to fill the cistern in a space of time considerably less than the hours during which the water is on. The usual system is to have the cistern provided with a ball-cock—*i.e.*, a cock which is turned by an arm, at the end of which is an empty copper ball, which must be air-tight; this is self-acting, for, as the water rises, it turns off the tap and closes the supply, any surplus passing off through the waste-pipe or overflow. This pipe usually enters the cistern at the bottom, and should always be considerably larger than the supply or service pipe, so that in case of any accident interfering with the action of the ball-cock the superfluous water may pass down the waste to the drain, instead of overflowing in the house. The usual course is to screw into a brass union at the bottom of the cistern what is usually called a "trumpet waste," of the exact height of the contained water; the narrow end of this is screwed into the bottom, and the upper end opens out in a trumpet form about three or more inches in diameter, to allow of a ready escape of overflow water; when the cistern has to be cleaned out this can be unscrewed and the cistern emptied and thoroughly washed, the water in this case being drained from every part.

Another common source of trouble and damage in water-supply is frost. In an unusually severe winter it is not uncommon for half the houses in a street to have the water frozen in the pipes; the natural expansion that takes place when the water is frozen bursts the pipe, but the mischief is not apparent until the thaw comes, when of course the house is deluged. This may be obviated in various ways, by a careful arrangement of the supply-pipes, so that no portion of them shall be exposed to the external air, and that if possible they may for the greater portion of their course run up along the side of a flue in constant use. Sometimes an arrangement has been made by which in cold weather a small gas-jet maintains a slight warmth at a certain part of the pipe, which in this case must be iron. This affords a sufficient protection to the general supply, but is not usually done nor generally understood. In the course of last winter one house in a street in a first-rate West-end neighbourhood thus provided was the only one that maintained its supply uninterrupted throughout the winter. Nothing is more common in suburban districts than to see the supply-pipe outside running up to the cistern which forms a portion of the roof of some back building. When this is the case, failure in case of frost is a certainty; and the only method of protection from freezing, fracture, and subsequent flooding is, the moment the frost becomes sufficiently severe to threaten the pipes, to have the water turned off at the main, and then *empty the pipes* by letting all the water run away from their lowest point; the supply will in any case be stopped by the frost, but by adopting this precaution all risk of consequent damage is avoided. In all grouped buildings—such as the model-lodging houses, now becoming so numerous, and the sets of residential chambers, every year coming into fashion—unless some artificial means of warmth are adopted for protection, this course should invariably be adopted. We may mention that at the immense groups of chambers in the Temple, some of ancient and some of modern construction, where the water-supply is of course very various and complicated, this precaution of emptying the pipe in case of hard frost is invariably adopted with success.

Having thus dealt with some details of the manufacture and arrangement of pipes, we shall in our next paper take up

some similar questions as to the manufacture and material of cisterns; and then proceed with some of the details of what we may call internal systems of plumbers' work, giving particular attention to a point which does not usually receive sufficient notice—*i.e.*, the ventilation of the pipes.

CHEMISTRY OF THE FINE ARTS.—VI.

By Professor CHURCH, Royal Agricultural College, Cirencester.

PRESERVATION AND RESTORATION OF PAINTINGS IN OIL—OIL PAINTING—PAINTING WITH WAX AND PARAFFINE.

THE method of silicious painting described in our last paper is that which has received the most extended trial, and has led to the most successful results. Not only, however, does it admit of improvement, but it is quite possible that some other process of painting based, like it, upon the employment of a chemical product, may ultimately replace it. Already many suggestions in this direction have been made. A mixture of potassium silicate and potassium aluminate in solution has the property of spontaneously solidifying after a time, and may be used with pigments to fix them on a prepared surface. The silicate is to be of specific gravity 1·2, and the aluminate of specific gravity 1·12. A solution of phosphoric acid, or of monocalcic phosphate may be similarly employed upon any ground with which baryta, lime, or lime compounds have been mixed. Until these methods, and others which we could name, have been submitted to further experimental proof, it will suffice for us to name them here, with the expression of a hope that some artist of eminence will try their merits.

In speaking of the chemistry of oil painting, it will be judicious to introduce a few words in the first place upon painting-grounds. It is of the very first importance that the canvas, panel, or millboard on which a picture is to be painted, should present certain characters of permanence. Canvas made from hemp or linen is in its nature liable to a daily alteration of weight and size, owing to variations in the amount of hygroscopic water or moisture which it absorbs or retains. Unprimed canvas may contain on a dry day 5 per cent. of water, and on a damp day 11 or even 12 per cent. By saturation of the canvas with some water-repellent material, such as oil, wax, or paraffine, the variation we have named may be almost entirely prevented. A solution of paraffine in mineral turpentine, or of copal varnish in ordinary spirits of turpentine, or a mixture of these two liquid preparations, may be used to saturate a canvas or a mill-board before laying the priming or ground upon it. The canvas, etc., should be carefully and slowly dried, at a temperature not exceeding that of boiling water, before saturation with the waterproofing liquid; and of course an equally thorough drying is necessary afterwards, before the priming is laid on. It is difficult to treat panels in the same way, but if they are of well-seasoned wood, and their back and front surfaces are of equal age—that is, have been equally long exposed to the influence of the air, the best mode of preventing their warping and cracking is to charge the back of the panel with as heavy a coat of paint as that which the finished picture on the front may be presumed to contain. The saturation of canvases, panels, etc., with any preservative solutions such as those named above, may be best accomplished by their immersion in the prepared liquid in a chamber partially exhausted of air. On re-admitting air, the liquid fills the pores of the material much more completely than is the case where it is merely painted over the surface. To saturate ivory with paraffine, etc., previously to painting upon it, is quite easy if the ivory be immersed in a vessel of melted paraffine, and then placed on a heated iron or brick, under the receiver of the air-pump. It has been* recommended "to steep the canvas before painting in a solution of silicate of potash. If the canvas is steeped in this solution and carefully dried, and then stretched and painted, it will preserve its soundness for many years, the silicate acting as a protective covering to the fibres of the hemp of which the canvas is made." It is impossible for any one who has studied the action of soluble silicates upon vegetable fibres, either in the case of tent or picture canvas, to join in this recommendation. With a potash water-glass as free as possible from excess of alkali, it will be found that the fibres of the canvas will be—firstly, discoloured, and the discoloration will find its way through the ground to the picture; secondly, that the fibres will be seriously weakened; and, thirdly, that they will be rendered still more hygroscopic than before. If any preparation of silica be selected for trial, we should suggest the use of a solution of pure silica in water, prepared by Graham's method of dialysis; but although direct experiments do not tend to show that such a preparation is of much use for the improvement of canvases, it cannot discolour or weaken them. We shall have to recur to this subject presently, in speaking of the preservation and restoration of paintings in oil.

A bad practice of priming and grounding canvases with size and whiting is very general. This preparation, however well it may stand in a dry climate and pure air, is not permanent under the atmospheric conditions of a modern English city. Nor is the free use of plaster of Paris in grounds a safe employment of this substance. Although such grounds as these may adhere strongly to the canvas at first, they often become loose after the lapse of some years, and crack in all directions. There is, in fact, a certain degree of incompatibility, as it is called, between the material and medium of the ground on the one hand, and the medium of the subsequent painting on the other. Unequal contractions occur, while the ground and painted surface alike become fissured. A really good ground may, however, be made by means of white lead ground in oil, and mixed with a little pure, pale picture copal. Upon this surface, while it is still tacky, dry and warm zinc white should be dusted. This will adhere in part, and form a dead white surface, very suitable for throwing brilliancy into the subsequent layers of colour.

We have before spoken at length of the pigments and media used in oil painting, and we have here but to add some details as to the modes of using them—so far at least as chemical actions are concerned. Now, when we recall the ingredients of the various media used in oil painting—oils, resins, turpentine, essences, with, in some cases, wax and paraffine—we shall see that the change of conditions from a soft state in which the pigment may be laid on in fine lines with a brush, to a state of very considerable hardness, is brought about by two actions going on in the media. One of these actions is the evaporation of the essential oil or spirit, the other is the absorption of oxygen. Both actions tend in one direction, the hardening of the cement which binds the particles of the pigments to each other, and to the painted surface. But it is evident that neither the evaporation of the volatile part of any medium nor the oxidation mentioned above can proceed properly if the ground be not thoroughly dry before the first layer of paint be placed upon it; and so on with each successive addition of pigment. A good rule deduced from this observation is to make a point of employing the most rapidly drying medium first, and afterwards, if any change be made, it should be in the direction of a slow dryer. By using a variety of oils, and megilps, and varnishes, some rapid and some slow in drying, and some disinclined to dry at all, the most fatal results ensue to the coloured films which constitute the picture, and which are pulled about and torn in all directions. If copal varnish, with poppy or linseed oil, be the medium in use, then in the later paintings more oil and less copal should be employed. Further, six months at least should elapse before the finished painting be varnished, the varnish itself being thinned suitably and laid on rapidly, evenly, and lightly. Before each successive painting, and before varnishing, it is often necessary to adopt some plan of preventing the new coat from "rolling," as it is termed, in beads or drops, instead of becoming smoothly distributed over the last painting. To moisten the previous layer with saliva is a usual but a reprehensible practice. It endangers the safety of the new film of paint, for water subsequently applied to the painting may penetrate to the residual matter of this saliva, and dissolving it away, loosen the coloured film above it. Sponging the unfinished picture first with a weak solution of ox-gall, and then with distilled water, is a far more satisfactory way of cleansing it and preparing it for subsequent painting or varnishing. Or the painted surface may be exposed for a few minutes in a box, to air charged with alcohol vapour.

The common practice of "laying in" a work intended to be completed in oil with water-colours is most unsafe. Exactly the same objection applies to it as to the use of saliva just described, only in a tenfold degree. Some painters, however, go so far as to paint with water-colours mixed with a little

* Professor Barff: *Journal of the Society of Arts* (1871), Vol. XIX., page 156.

ox-gall many of the minuter details and rich glazings of their pictures, trusting sometimes to a little oil or varnish to keep these water-colours in their places. Possessors of pictures thus made up will sooner or later discover the ill effects of such tricks. Fissures will form, changes of tint take place, and if the picture be at any time submitted to any of the common cleaning and washing processes, the rich and delicate water-colour work will be wholly carried away, taking with it, it may be, many a thin glazing or scumbling in oil, precious from an artistic point of view, but held in its place by a too precarious tenure.

We have hinted, in former papers, that it is possible to make certain changes for the better in the media of oil painting. The following substitutions are amongst those which promise well. For turpentine and other essential oils liable to resinify and darken, use benzole and toluol—hydrocarbons abundantly found in coal-naphtha. For the fixed drying oils, substitute, wholly or partially, the purest paraffine or hard white beeswax. For mastic and dammar varnishes, substitute the best sort of pale copal varnish. These alterations must be made with judgment, and according to the purposes for which the medium is desired. In mural decorations, more particularly, advantages will accrue from the substitutions just named. For such a purpose the pigments must not present a heavy appearance, nor must the finished work show any surface gloss. The following recipe enables us to prepare a mural medium of great permanence and very easy working:—

Melt four ounces by weight of pure, hard, white paraffine, in a tin can or glass flask standing in hot water; then add, very slowly, eight fluid ounces of benzole, toluol, or the mixture of hydrocarbons contained in light coal-naphtha, boiling between 80° and 120° C. Then, still keeping the flask in hot water, add twenty-three fluid ounces of pure copal varnish, and thoroughly mix the contents of the vessel. In this formula pure white beeswax, which has been granulated by pouring it into cold water, and has then been washed in methylated spirit and again melted, may be substituted partially or wholly for the paraffine. So, too, oil of spike lavender, or even spirits of turpentine, may be used instead of the coal-naphtha. The copal varnish is best made as directed in Article III., using the white, hard, Sierra Leone copal resin if possible. This medium presents great resemblance to a wax medium which was recommended some years ago for mural work by that distinguished painter, Mr. Gambier Parry, of Highnam Court, Gloucester. This amateur artist has executed some noble works in a preparation containing wax, resin, elemi, oil of spike, and copal varnish. Some of the best and latest of these decorate the walls of St. Andrew's Chapel, in the Cathedral of Gloucester. Others, which have stood well several years, are in Highnam Church. In Mr. Parry's process, as in all other processes of a similar kind, the wall should be prepared with a pure fresco ground, allowed to become quite dry and hard; but a coarse sand is not advisable, as the pigments may be rubbed off from the prominences made by these grains. The wall to be painted should be saturated with a mixture of the medium employed, and some liquid solvent, such as the essential oils or hydrocarbons used in preparing the medium. When this is dry, the pigments, ground preferably in the medium rather than in oil, are laid on in the usual way. If it be desirable to thin the medium, it may be done partly by warming the tube or can holding it, and partly by adding some one of the fluid solvents just named.

There is one subject connected with the practice of oil painting which demands a few words of remark here. We refer to the varying amounts of oil which different dry pigments require, in order to bring them into that condition in which they may be used by the artist. The variations are so great and show so distinctly how much *binding material* one colour requires and how little another, that a list of the chief results of Herr Wurm's investigation of the subject may prove practically useful. This experimentalist finds that—

100 parts by weight of		white lead	require	12	parts by weight of oil.		
"	"	zinc white	"	14	"	"	
"	"	chrome green	"	15	"	"	
"	"	chrome yellow	"	19	"	"	
"	"	vermilion	"	25	"	"	
"	"	colcothar	"	31	"	"	
"	"	madder lake	"	62	"	"	
"	"	yellow ochre	"	75	"	"	
"	"	terre verte	"	100	"	"	
"	"	Prussian blue	"	112	"	"	
"	"	bone black	"	112	"	"	
"	"	cobalt blue	"	125	"	"	
"	"	burnt sienna	"	181	"	"	
"	"	raw sienna	"	240	"	"	

There are two sets of conditions which have to be considered in reference to the preservation of cabinet and gallery pictures painted in oil. One set of conditions has reference to the materials themselves of the picture, the other to its atmospheric and other surroundings. When the canvas, etc., the ground, the medium, and the pigments are satisfactory, the picture is still liable to injury from alteration in the size and form of the canvas or panel—alterations which may arise from excess of dryness as well as of damp, or from inequality of temperature. With the canvases of pictures, as ordinarily prepared, extreme dryness* of the air is as much to be dreaded as extreme damp. If a stream of warm and dry air enters a gallery just below the pictures, the canvases, frames, and panels become altered in shape and size each day, returning more or less to their original state each night. Thus the coloured films of the painting are submitted to an injurious strain, which may end, as the binding medium of the pigments becomes more brittle, in a multitude of minute fissures, and the final flaking off of portions of the paint. One day the canvas of a large picture may be tightly stretched; another day it may bulge out in an awkward manner. A panel may warp and even split from the same causes. A picture-gallery ought, then, to be kept at a mild and uniform temperature, and the atmosphere should be sufficiently charged with moisture to maintain the hygroscopic water of the canvas, etc., in its due and normal proportions. A registering thermometer will indicate how far the first condition is fulfilled; the realisation of the second may be estimated by a piece of primed canvas suspended in a light frame of metal from a delicate spring balance. The index of this balance will show the steadiness or fluctuation of the atmospheric moisture. And here we may suitably enter a protest against hanging pictures close to a wall, and against the ordinary plan of glazing pictures (in water as well as oil), especially where the range of temperature is great; the transference of water to and from the picture to the air-space in front of it and the glass exerts a most injurious effect upon the materials of the painting, and encourages the growth of minute vegetable organisms. And it may be further stated that the modes in which pictures are fastened into their frames do not permit with sufficient freedom of those minute movements which are inevitable, and the causes of which we have been at some pains to explain. It is scarcely necessary to say that air, impure from the presence of ammonia or sulphur compounds, or of coal-gas and its products of combustion, is most injurious to the permanence and preservation of paintings in oil. Air may be filtered through muslin, or even washed with advantage before it enters the gallery. So, too, the exclusion of soot and dust is of the greatest moment. A picture-gallery should never be entered except by means of passages and lobbies, where the dust which visitors bring in, or which the outside atmosphere contains, may be removed, or may settle. The floor should, for the same reason, be adapted to show dirt, not to harbour it. Projecting frames, and the inclining forwards of the upper part of the picture, will tend to prevent the lodgment of dust upon the painted surfaces.

A few notes on the restoration of pictures must not be omitted. Hitherto, the restoration of a clouded or damaged picture has too often proved to be its destruction as a work of art. The plan followed was the removal of the discoloured varnish by means of spirits of wine, with occasionally certain additions of oil and spirits of turpentine, to modify the solvent action of the alcohol. As some amount of friction was employed in applying the liquid, delicate touches and glazings were often wiped out, so that the work of re-painting became necessary. But the method perfected by the German chemist, Dr. Max Pettenkofer, presents in many cases a great superiority over the former plan. It consists essentially in the exposure of the picture, previously washed with pure water, to the vapour of alcohol of 80 per cent. The operation is conducted in a closed shallow box, to the lid of which the picture is fixed, face down-

* *Journal of the Society of Arts* (1871), Vol. XIX., page 153.

wards, and on the bottom of which a piece of flannel, moistened with alcohol, is firmly attached. All dust must be excluded throughout the operation, while the progress of the solvent action of the vapour on the varnish must be watched with care. In the case of pictures painted on canvas the process may be completed by spreading a thin layer of copaiva balsam on the back of the picture. But it would extend our lesson too much were we to enter into a full description of the several steps in the "regeneration" of pictures by Pettenkofer's method. For such details we must refer to a pamphlet,* in which the process and its results are fully given.

TECHNICAL DRAWING.—LXIII.

DRAWING FOR BRICKLAYERS.

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

Brick and Tile Paving.—Paving formed of bricks on their edges affords a much better floor, and is in some cases preferable to stone paving, if the latter be laid on the ground without the intervention of footings. Brick-on-edge paving in sand is generally used in beer-cellars, pantries, dairies, stables, etc., as its numerous open joints allow wasted or discharged fluids readily to escape, and it is both cool and dry under ordinary circumstances. In mortar or cement, bricks on their edge (Fig. 521) form a sound dry floor; the smallness of the surface exposed by each brick in this manner leaves them, of course, less susceptible of partial pressure, and the depth from the soil to the surface is such that damp rarely shows through.

The paving brick differs from the common brick only in thickness, its dimensions in that direction being $1\frac{3}{4}$ inch; it is, however, rather harder and more compact.

Dutch clinkers are paving bricks, smaller and much harder than the English; they are $6\frac{1}{4}$ inches long, 3 inches wide, and $1\frac{1}{2}$ inch thick, and are always set on edge and herring-boned—that is, instead of being placed in parallel lines, they are set at right angles to each other, as shown in Fig. 522, the face being kept perfectly even.

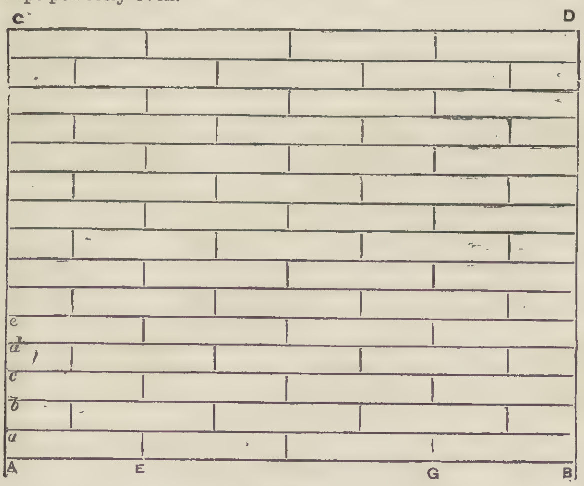


Fig. 521.

Common paving tiles are made $11\frac{3}{4}$ inches square and $1\frac{1}{2}$ inch thick, and $9\frac{3}{4}$ inches square and 1 inch thick. These two sizes, however, are respectively called "twelve-inch" and "ten-inch" foot tiles. They are laid in courses as stone paving would be, the alternating courses breaking joint.

To copy Fig. 521, having drawn the lines A B and A C at right angles to each other, and having completed the rectangle A B C D, set off on A C the points *a*, *b*, *c*, *d*, *e*, etc., representing the widths of the *edges* of the bricks, and from these points draw lines parallel to A B.

These lines will give the separate courses, and lines drawn from points E, F, G will divide the first course into separate bricks, the length A E, etc., being nine inches by scale (the scale used in this subject is an inch to the foot).

* "Über Ölfarbe," etc. Max v. Pettenkofer. 1870.

The second course is placed so as to break joint—that is, the joints fall in the middle of the whole bricks adjoining. These two courses will serve as guides for all the rest, and the T-square having been placed so that its cross-head is guided by the left-hand edge of the board, the blade extending across it, the lines referred to are to be drawn with the set-square, guided by the edge of the blade.

Fig. 522 is a portion of a floor, executed in the manner called

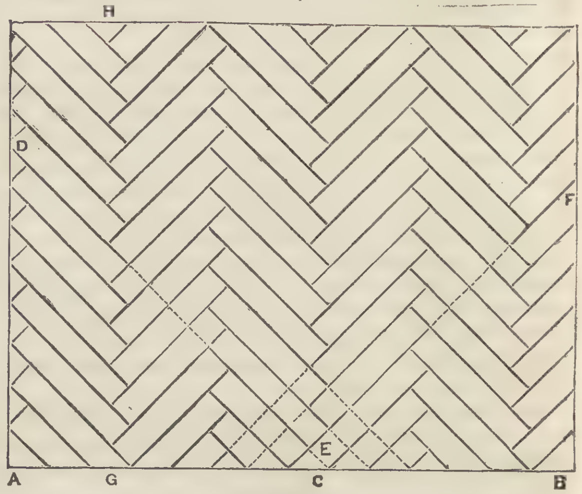


Fig. 522.

"herring-bone brick on edge." In commencing this, draw the line A B, and at any point in it, as C, draw C D at 45° to A B, which will be easily done with the aid of the set-square (of 45°).

From C set off on C D any number of divisions equal to the widths of the side of the bricks. Through either one of these points, as E, draw a line at 45° in the opposite direction to C D, and from E set off to E F divisions corresponding to those on C D. The entire example is then to be completed by drawing lines through the points in these two lines, the whole being simply a chequer pattern, as shown at C.

It must be pointed out that the angles of the bricks must fall in straight lines at right angles to A B. This would be plainly seen if a line were drawn from G to H, and is a test which must be constantly applied during the progress of the work.

When the drawings have been inked they may be coloured. A few brief instructions on this head will be found further on.

Fig. 523.—This study is taken from a German pavement formed of bricks laid flat. It is used as the floor in a kitchen, and the bricks, which are 10 × 5 inches, are laid in cement.

The method of drawing this subject is very simple, for, since the bricks are doubly as long as they are wide, the whole surface may be divided into squares, two of which will make one brick. This floor is sometimes worked in black and red, and sometimes in red and buff bricks, in either of which it presents a very pretty appearance.

Fig. 524.—The pattern of this floor is formed of whole and half bricks, of the same size as those used in the last; and in copying it the surface should, as before, be divided into squares. The bricks used are black, red, and buff.

Paving in various stones seems to have been the origin of what has since been called "mosaic work." The fine effect and use of pavements composed of pieces of marble of different colours so well joined together as that when dried they might be polished, and the whole make a beautiful and solid body, which, continually washed with water and trodden upon, was not at all damaged, gave the painter the hint, and thus originated inlaid representations of borders, geometrical patterns, figures, etc. But the number of colours in marble being limited, variously coloured glass and even metals were employed.

This kind of work is supposed to have originated in the East, and was most likely brought from Phœnicia to Greece, and thence to Rome, where it was used principally for pavements. Many of these were exceedingly beautiful, and several excellent specimens have been found in this country.

A very fine Roman tesselated pavement was discovered when digging to lay the foundations of the old India House (now removed), in Leadenhall Street, in 1803. This was as a whole square, with a circular disc in the centre, on the white ground of which was inlaid a figure riding on a tiger. This was surrounded by various borders, the principal of which was the "wave scroll." The spandrils at each corner were filled in with vases, from the handles of which spiral scrolls diverged. Next came a square border of a chainlike character, and another filled with ornamental devices.

Fig. 523.

Another magnificent specimen was found in Somersetshire, in 1737, the general pattern of which was made up of numerous compartments filled in with geometrical devices, and the whole was surrounded by the Greek key or "fret" border; and a second pavement of a similar character was found in the same county in 1738, and only a few years ago a beautiful specimen was found in the Poultry, London. For accounts of several discoveries of remains of ancient work of this description, the reader is referred to the "Lessons on Mosaic Work," in which several beautiful examples are figured.

As a rule, these pavements consisted, as in the first specimen alluded to, of borders surrounding a central figure or device, and sometimes a group or subject. Others consisted solely of patterns worked out in two or three colours, usually black, white, and red.

The material of which the mosaics of the Middle Ages were formed was chiefly glass, by which they are in a great measure distinguished from the Roman work.

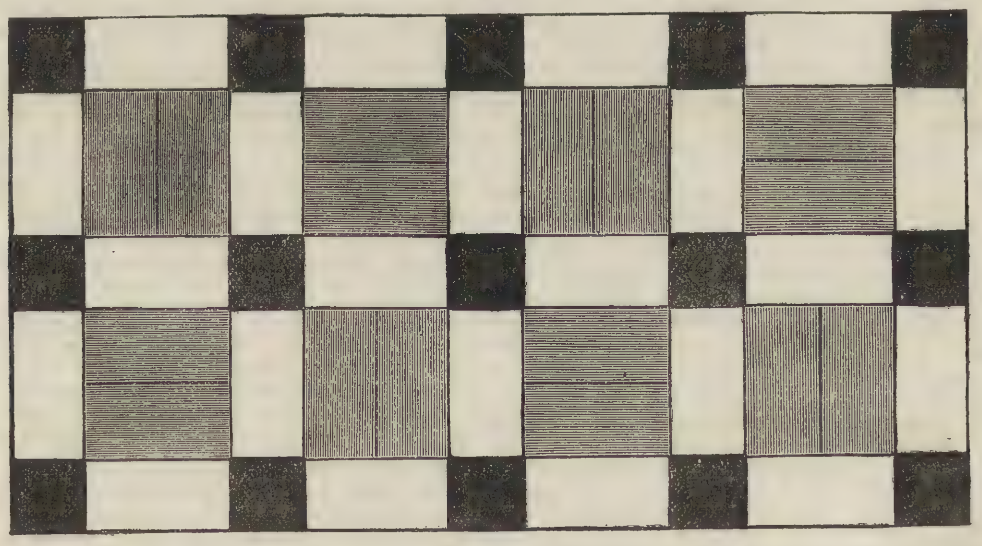


Fig. 524.

Perhaps the nearest approach to manufacture is to be found in the rude inlaid work of the columns and fountains which were discovered in some of the gardens of the buried city of Pompeii. Mosaic work is also common in Arabian edifices, so much so indeed as to become a feature of the style. Their mosaics were principally of porcelain, and were employed in the decoration of the lower parts of the walls and also for pavements.

NOTABLE INVENTIONS AND INVENTORS.

XXVII.—JOSEPH BRAMAH.

BY JOHN TIMBS.

THIS celebrated mechanician was born on the 13th (New Style) or 2nd (Old Style) of April, 1749, at Stainsborough, in Yorkshire, where his father was a well-to-do farmer. He was the eldest of five children, and was intended for his father's occupation; but he very early indicated proofs of mechanical genius, and being at the age of sixteen incapacitated for agricultural labour by lameness, he was apprenticed to a carpenter and joiner. He next removed to London, where he worked for some time as a journeyman cabinet-maker, and afterwards set up in the same business for himself. He was led to that of an engineer or machinist by his invention of some very important improvements in the construction of water-closets, whence he became a manufacturer of those articles. His next important invention was the ingenious lock still known by his name, and which, after a lapse of seventy years, during which time many new kinds of locks have been introduced, maintains its character as one of the most inviolable locks ever contrived.

By far the greater part of the almost innumerable ingenious contrivances for rendering locks inviolable, may be classed under one of two systems of security. The first consists of the insertion in the lock of fixed obstacles, commonly called wards, which prevent the entrance or revolution of any instrument or key which is not formed with corresponding openings, so as to thread its way among them, and thus render the bolt inaccessible to any but the proper instrument; while the second consists in the use of movable impediments, which in their most general form are called *tumblers*, a term which, for convenience, we may apply generally to the motion of the bolt itself, the security arising from the difficulty of bringing these movable impediments, by the use of any but the proper key, to the actual and relative positions necessary to allow free motion to the bolts. It is curious to find that this kind of lock is of great antiquity. According to M. Denon (in whose magnificent work on Egypt it was published), from the circumstance of finding one sculptured amongst the bas-reliefs which decorate the great Temple at Karnak, it was ascertained that during forty centuries the lock had undergone no sensible change. (Ainger on Locks.) Notwithstanding the high antiquity of the tumbler principle, its first important application in this country appears to have been made by Barron, in 1774 or 1778. In the simple form of the tumbler there is the disadvantage that, while it effectually prevents the removal of the bolt unless the tumbler be raised high enough, it presents no obstacle to its removal when, by the use of a false key, the tumbler is thrown up beyond the proper degree. This defect is remedied in Barron's lock, and in many more recent contrivances which are based upon it, by the use of several tumblers, each of which requires to be raised to a different degree, and any one of which, if lifted too high, will form as effectual a barrier to the motion of the bolt as if it were not lifted at all.

Bramah's lock was invented and patented in 1784, when he pronounced it "not to be within the range of art to produce a key or other instrument, by which a lock on this principle can be opened." In Bramah's lock, the principle of tumblers or movable obstacles is applied differently to that in others, and the use of wards is entirely abandoned. In a kind of prefatory record which was attached to his specification, Bramah alludes to the insufficiency, for the purpose of security, of all contrivances of the ward, or fixed obstacle character, because, according to Holland's abstract of his argument, "the variations capable of being made in the disposition of such wheels or wards, and in the form of the key's bitt, are not sufficient to produce the required number of locks, without having large quantities exactly alike, and their keys capable of opening one another reciprocally. In consequence of which they become a very imperfect security against violation, as any ill-disposed person might, by furnishing himself with a number of old keys, be enabled to open almost all the common locks in the kingdom, with as little difficulty as if he had in his possession the key belonging to each lock." In devising a remedy for these defects, Bramah contrived a method of applying more impediments, very different to that adopted by Barron. Retaining the principle which required the withdrawal of every such impediment in its own peculiar movement, he provided for restoring them, by the application of an elastic force, in such a position as should leave no trace and afford no possible clue to the discovery of the extent of their motion under the presence of the key; so that the opening of his lock without the true key is, to use his own expression, "as difficult as it would be to determine what kind of impression had been made in any fluid, when the cause of such impression was wholly unknown; or to determine the separate magnitudes of any given number of unequal substances, without being permitted to see them; or to counterfeit the tally of a banker's cheque, without having either part in possession." To explain how the principle of security is applied in Bramah's lock, we should explain that the ordinary mode of shooting the bolts by the action of the bitt of the key is entirely abandoned in it; the office of the end of the bitt being performed by a stud attached to the end of a cylindrical barrel, which is mounted in the lock, and which contains all its essential parts, or rather, all the parts essential to its security. The portability of the key constitutes a great advantage to this kind of lock, as a key which may always be carried in the waistcoat pocket, or even attached to a watch-chain, is less likely to be mislaid, or to fall into the hands of improper persons, than a large key. Again, both locks and keys, being made almost wholly by machinery, may be made with great accuracy at a moderate cost; while the production of a false key from an impression of the true key, or even from the key itself, would be no easy task to a person not possessed of the requisite machinery. For some time after the introduction of this lock it was deemed absolutely inviolable, but ingenuity at length overcame the difficulty of picking it. This was accomplished by what has been aptly termed the *tentative* or *trying* process. Force being applied to the barrel in such a way as to give it an inclination to revolve on its axis, the picker tried all the sliders in succession, to ascertain which of them, by the inevitable inaccuracy of workmanship, pressed with most force against the circular locking-plate. This slider he then gently pushed, until, by the cessation of the resistance of its locking-plate, he found that its notch was in the required position; when, having secured it, he proceeded to adopt the same course with each of the other sliders in succession. Then, by an extraordinary exercise of patience and delicacy of hand, etc., a very skilful operator was able, in many instances, to accomplish the apparently impossible feat of picking a Bramah lock. No sooner, however, was this fact made public, than an efficient remedy was provided by a person named Russell, who was then in Bramah's establishment, by the simple device of cutting one, two, or more additional or false notches on each slide, and enlarging the inner portion of each notch on the locking-plate. The result is that it is utterly impossible for a picker to know whether he gets the true notch, or one of the false notches, on to the locking-plate; while, supposing him against all probability to find the right notch in a majority of the sliders, the fact of one only hanging on a false notch would be sufficient to prevent the barrel from turning, owing to the depth of such notch being insufficient to clear the plate. The enlargement of the notches in the locking-plate, which allows of a degree of motion far exceeding any which could arise from mere inaccuracy of workmanship, adds to the baffling effect of the false notches, by the use of which the Bramah lock may fearlessly be said to be rendered, so far as any mechanical contrivance can be, perfectly secure from picking. The same principle of picking, and the same kind of security against it, with variations of detail, which need not be noticed here, have been applied to tumbler locks of the more ordinary construction.

The infinite variety attainable in the manufacture of locks on this principle forms one of its great recommendations. In one of its simplest forms only four sliders are used; but even in this form the variety attainable without any difference in the size of the key, or the diameter of the central pin, is very great. By the use of five, six, or seven sliders, the number of different locks, each of which may have the same external appearance, but can be opened only by its own proper key, is increased almost to infinity. Bramah himself showed that if twelve sliders were employed, the number of changes which might be produced by simply varying their relative positions would amount to 479,001,500; while, by adding one more slider, the number would be increased to 6,227,019,500; so that, as he

observes, "one lock, consisting of thirteen of the above-mentioned levers, sliders, or other movable parts, may (by changing their places only, without any difference of motion or size) be made to require the same immense number of keys." It may be observed that, in the event of a key becoming lost, or the owner desiring on any account to have a lock altered, it is possible to change the relative positions of the sliders, so as to render the old key useless; and also that *master-keys* may be made, if required, by constructing a suit or set of locks, alike in everything but the position of their notches, and then applying to each of them in succession the intended master-key, which must have notches different to any of the ordinary keys, and cutting new additional notches in the sliders to suit it. Such, indeed, is the principle upon which the notches of ordinary Bramah locks are cut, the key not being fitted to the lock, but made first, showing its notches cut by a machine which provides for a continual change in their order and depth. This done, each key is applied to a separate lock, with blank or uncut sliders, and the notches in the sliders are cut while they are thus held in the proper position by the key. By any other arrangement it would be almost impossible to secure the requisite accuracy.

Bramah, it may here be observed, presents us with an early example of a man of genius extensively applying machinery to manufactures. Thus, when he set about his famous lock, he constructed a series of machine tools for shaping with the required precision the barrels, keys, and other parts of the contrivance; this would have utterly failed, had not the tools been formed with the accuracy which machinery alone could give. The importance of such perfection has of late years been much more generally appreciated than in Bramah's time.

In Bramah's workshop was brought up the celebrated Henry Maudslay, who went there as a young man of eighteen. Bramah was then engaged upon his lock, and was at his wits' end for the means of simplifying its various parts. He was almost ashamed to apply for assistance to the youth of eighteen; but he did apply, and got the most valuable aid from Maudslay, who was working in Bramah's shop for little more than a pound a week.

It is not within our province to pursue Bramah's lock further than to state that it was greatly improved by the inventor's sons. It was, however, picked in 1817, when it was improved by the introduction of false notches. It was again picked in 1851. There hung in the window of Messrs. Bramah, in Piccadilly, for twenty years, a padlock, to which was appended a label with these words: "The artist who can make an instrument that will pick or open this lock shall receive 200 guineas the moment it is produced." The lock contained no less than eighteen sliders, and supposing the projecting surface of each slider to admit of only six different situations for each notch, it presented a sum of security as compared with unity of 678,651,612,807,168,000. How many lives would it take to hit by chance upon the right key out of so many changes? A long controversy ensued as to the actual compliance with the conditions of picking: the case of Messrs. Bramah was referred to a committee of arbitrators, who, having witnessed certain experiments, decided that Mr. Hobbs, the American operator, had picked the lock without injuring it, and Messrs. Bramah accordingly paid him the 200 guineas, though he had used three or four instruments instead of one, stated in the challenge. The padlock is stated by Messrs. Bramah to have been imperfect; and they produced another lock, which they challenged Mr. Hobbs to pick, for 200 guineas. The *cui bono* of the affair has been thus pertinently illustrated:—"The public, while they admire the expertness with which this mechanical feat has been performed, will not attach more importance to it than it deserves, or undervalue the merit of our best locks, because an American operator, highly accomplished in such matters, has succeeded, after an arduous struggle, in opening them. The facilities given to him were such as no thief could ever possess, even if he had the necessary ability; and it is quite clear that the operation has not been one of ordinary picking."—*Times*, September 4, 1851.

To return to the career of Joseph Bramah. From the lock he turned to the steam-engine, and made several valuable improvements in it. Stuart observes: "After a series of experiments, in which Watt had been engaged for twenty years, to develop his ideas, the splendid result of his genius and perseverance—the perfect machine—was raised up in judgment against him, to prove that between the years 1790 and 1800, the engines which were sent from Soho were more perfect than could be fabricated from the description he gave of the one he erected in the year 1760." Bramah, whose own distinguished ingenuity and personal acquaintance with the subject, joined with his high integrity and regard for truth, rendered him a dangerous adversary, was enlisted among the determined opponents of Watt's patent. This he attacked safely on the ground just stated, while his printed letter to the judge who presided at a trial on which he had appeared as a witness, is referred to by Stuart as being throughout a series of admissions of the value of Watt's contrivances, in which "he points out inventions that had escaped the notice of others, with all the fine feeling of what is beautiful in an art in which he was himself a master; while he ceases not by inference to ask if the inventor has described these in a proper manner; and he comes always to the same conclusion, that because he has not, therefore he is not entitled to any reward for his superlative invention;" although, after a series of trials extending from 1792 to 1799, a unanimous and clear decision was given, fully vindicating and establishing the rights of the patentee.

Bramah's greatest invention is the hydraulic, or, as some persons erroneously term it, the hydrostatic press, patented by the inventor in 1796. It has therefore been known to the world for seventy-five years, and is now applied in a multitude of operations, which absolutely could not be performed at all without it. The boundless power which it enables one man to exert, renders it an important agent in many manufacturing processes, one of which is the powerful hydraulic discharging press used in the manufacture of bandana handkerchiefs. Thus, in the Barrowfield Dye Works, near Glasgow, there are sixteen presses for the production of bandanas; and when these are in full work, the period required for the complete discharge of the colour in the first press is equal to that required for bringing the remaining fifteen into action, so that one discharger, with his assistants, can keep the whole in constant operation. The entire routine of operations occupies about ten minutes, so that the sixteen presses (each producing fourteen handkerchiefs at each operation) will produce 224 handkerchiefs at each time of working; the whole being completed within the short space of time mentioned above, and by the aid of powerful and ingenious machinery requiring only the labour of four men to effect the various necessary changes and adjustments.

The hydraulic press is of very great power in compressing bodies or lifting weights; or again, in drawing up trees by the roots, or piles from the beds of rivers. Its power in compressing woollen and cotton goods is well known, and reducing hay to such dimensions as to be easily packed on board transports. The press acts on the principle of the philosophic toy called the Hydrostatic Paradox. When Pascal, in 1653, was pursuing his experiments on the weight of the air, in order to determine the general condition of the equilibrium of fluids, he fixed to the upper end of a cask set upright a very long and narrow cylinder. In filling the barrel, and afterwards the cylinder, the simple addition of a pint or two of water, which the latter was capable of containing, produced the same effect as if the cask, preserving its diameter throughout, had its height increased by the whole length of the cylinder. Thus the increase of the weight of a pint or two of water was sufficient to burst the bottom of the hogshead, by the immense augmentation of the pressure it occasioned. Now, if we suppose the water removed from the cylinder of narrow dimensions, and replaced by a solid of equivalent weight, such as a piston, it is evident that the pressure must remain everywhere the same. Again, if we suppose the weight of the piston to be multiplied by the power of a lever acting on its shaft, the pressure will be proportionally augmented, so as to produce on the bottom of the cask a pressure equivalent to an enormous weight, with the exertion of very little primitive force on the piston. ("Notes in various Sciences," 1827.) The most remarkable part of this discovery, and one which of itself would have immortalised Pascal, is his application of the general principle to the construction of what he calls *the mechanical machine for multiplying forces*, an effect which he says may be produced to any extent we choose, as one man may by means of this machine raise a weight of any magnitude. This new machine is the hydraulic press of Bramah.

How inventors help each other is well shown in the share Maudslay took in producing the hydraulic press for Bramah. Maudslay at once invented the leather collar, which, on the principle of a valve, tightens under the pressure of water. "Maudslay himself told me," says Mr. Nasmyth, "or led me to believe, that it was he who invented the self-tightening collar for the hydraulic press, without which it would never have been a serviceable machine. It is the one thing needful that has made it effective in practice. If Maudslay was the inventor of the collar, that one contrivance ought to immortalise him. He used to tell me of it with great gusto, and I have no reason to doubt the correctness of his statement." It was after this invention that Maudslay left Bramah, because the latter would not raise his wages beyond thirty shillings.

It has lately been stated in the *Engineer* journal that "Presses exerting a force of 500 tons, and having ranges of 10 feet, 12 feet, or even 15 feet, and being capable of exerting the above force at any part of the stroke, are by no means uncommon. We do not stretch a single point when we say that no arrangement of screws or levers could supply us with a press of equal range, power, or speed. It is not that an arrangement of levers could not be planned quite able to exert the strain of which we speak; but such an arrangement would lack all the characteristics which are essential to a mechanical device intended to serve the purpose of manufacturers. For example, had the work done in raising the tubes of the Britannia Bridge been performed by a simple lever, one arm must have been 448,000 times longer than the other, and to enable a pound to raise the weight through 100 feet, the pound must have passed through space for a distance of 83,522 miles. In simplicity, in cheapness, and in efficiency, the hydraulic press stands totally without a rival. Whether assuming the form of the gigantic apparatus employed in bending armour-plates, or that of a little 30 cwt. jack, it is equally compact, inexpensive, and elegant."

In the Museum of the Commissioners of Patents, at South Kensington, is deposited the "First Hydraulic Press ever made.—Joseph Bramah, Letters Patent, A.D. 1795, March 31. No. 2,045."

Next among Bramah's inventions is the well-known beer-machine, of universal adoption in taverns, for drawing liquor in the bar from barrels deposited in the cellar, by means of a force-pump. He also improved machinery for producing smooth and accurate surfaces on wood or metal; in making pens by a mechanical process, by which several nibs, resembling steel pens, were cut out of one quill, and fixed in a holder for use.

In the year 1806 Bramah contrived an exceedingly ingenious mode of printing, which was shortly afterwards applied to the numbering of bank notes, and by the introduction of which, during the issue of one-pound notes by the Bank of England, the labour of 100 clerks out of 120 was dispensed with. This machine consists of a number of discs, or wheels, with the numbers from 1 to 9, and 0 cut upon the periphery of each, the whole being mounted upon one axle, but capable of turning independently of each other. By the action of mechanism, which is incapable of error, the position of one wheel of the series is moved between each operation of printing, so that when the machine is properly adjusted it will print a series of numbers in regular progression, without the possibility of twice producing the same number.—*Penny Cyclopædia Supplement.*

In 1812 Bramah patented a scheme for laying mains or large water-pipes through the principal streets of London, of sufficient strength to withstand great pressure, to be applied by force-pumps; his object being to provide the means of extinguishing fires by throwing water without the aid of a fire-engine, and also to supply a lifting power applicable to the raising of great weights, by forcing water or air into an apparatus consisting of a series of tubes, sliding into one another like the tubes of a telescope, and capable of being projected when necessary. He asserted his ability to make a series of five hundred such tubes, each five feet long, capable of sliding within each other, and of being extended in a few seconds by the pressure of air to the length of 2,500 feet, and with such an apparatus he proposed to raise wrecks and regulate the descent of weights. By the construction of some waterworks at Norwich, Bramah acted with success in the department of the civil engineer.

The active life of this ingenious man was now drawing to its close. The last patent obtained by him was for a mode of preventing dry rot in timber, by covering it with a thin coat of Parker's Roman cement. He may be said to have died in harness, in consequence of cold contracted while superintending the uprooting of trees in Holt Forest by his hydraulic press, on the 9th of December, 1814, in his sixty-sixth year. He was a man of amiable private character, and his energy and probity in business were alike admirable. His works in Belgrave Place, Pimlico, were described in 1817 by a home tourist as "the manufactory of the ingenious Bramah, whose locks baffle knavery, and whose condensing engines promise such important results to philosophy and the mechanic arts."

FISH CULTURE.—VII.

By Greville Fennell.

THE STORMONTFIELD BREEDING PONDS AND APPARATUS—SUITABLE FOOD FOR NEWLY-HATCHED BROODS, ETC.

We now turn to the present year's report upon the Scotch salmon fishery, and learn much in the lesson which Stormontfield has afforded of late, that may have affected failures elsewhere. We give the text entire:—

"Stormontfield is now so well known to salmon culturists, that," says Mr. Buckland, "I shall not attempt to describe details. Suffice it that boxes of wood are sunk into the ground; water is conducted from a neighbouring mill-lade, allowed to pass through a filtering pond, and then flows through the boxes; the water is then conducted into two largish ponds. Without wishing to detract from the meritorious painstaking and expense of those who have instituted and worked the hatching apparatus, I venture to remark that the whole process, as now carried out, is capable of great improvement.

"The principal faults of the Stormontfield breeding-place are—

"1. That the stones in the boxes are a great deal too large, and there are too many of them in each box; the result is, that the eggs which fall down to the bottom of the box among the stones do not receive a sufficient current of water over them.

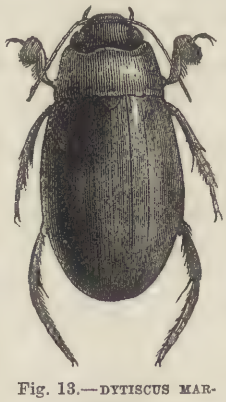


Fig. 13.—DYTISCUS MARGINALIS.

"2. Many eggs not properly impregnated in the first instance—technically called 'blind eggs'—die, become white, and are covered with a mildew like fungus, which is very detrimental to the healthy eggs, and also to the young fish when just hatched out, for it is very apt to give the fish also a fungus disease about the gills, called 'gill fever.'

"That the dead and fungus-covered eggs were still at the bottom of the boxes among the big stones long after the fish had hatched out I satisfied myself by personal examination.

"3. The little fish which hatch out properly must, I think, often have difficulty in getting out from under the big stones when their umbilical bag is absorbed, and the time arrives for them to feed. I saw several fish among the stones which were half starved. It is impossible to feed these fish when among the stones.

"The fish gradually fall back from the hatching-boxes into the ponds. This, I think, is wrong. The ponds themselves were full of dense banks of weeds, and a comparatively small space was left open for the fish, which, as is the habit of fish, had accumulated near the spot where the running water from the boxes comes in. These weeds must of necessity breed numbers of predatory water-beetles, *Dytiscus marginalis*, and to my personal knowledge there are no greater enemies to young fish than these beetles.

"The fish in these ponds must be fed artificially. I do not consider they have sufficient food, and it must be recollected that the food which escapes them falls to the bottom, and when decaying fouls the water. The remedy for this is to turn down common craw-fish to act as scavengers.

"When the migratory instinct prompts the young fish to descend to the sea in the spring months, they are enabled to

leave the ponds and get into the river by means of an artificial channel cut from the ponds to the river.

"I feel quite certain that a large number of smolts, hatched out with such expense and trouble, do not get down to the sea at all. The pike assemble at the mouth of the little stream down which the young smolts come, and eat a very large quantity of them, so that much time and money is expended simply for the benefit of the pike; I do not, I confess, know that this is the case from my own observation, but I feel most certain that it must be so.

"To obviate this mischief, I have strongly recommended the Tay District Board to have the river at and near the stream by means of which the smolts join the river netted regularly under proper supervision twice a day during the time that the smolts are on their downward march.

"The mesh of the net should be small, in order to catch the pike; all salmon and salmon smolts must, of course, be immediately and carefully returned to the water.

"Great praise is due to Mr. Peter Marshall for the manner in which he looks after the hatching apparatus; also to Mr. Brown, who superintends them; both these gentlemen do credit to the memory of the late Mr. Robert Buist, who was the founder of the first establishment in Scotland for rearing salmon by artificial means.

"Still I say, as is my duty, that the Stormontfield apparatus is capable of great improvement; and this—

"1. By using gravel sifted through an iron sieve with a half-inch mesh. The eggs should be placed on the top of these stones—not, as now, buried under the large stones.

"2. By covering the boxes with boards, so as to keep out the light.

"3. By netting the pike during the time the smolts are going down.

"4. By keeping the ponds clear of weeds; this will be best done by drying them entirely. Fish always do best in a pond which has been dried and re-filled with water.

"5. Best of all by sending the fish to the upper waters."

If properly managed, 80 to 85 per cent. of fish will hatch out. These need six times as much space as the eggs. From the time of the absorption of the navel-bag, the opinions and proceedings of the managers differ. Some say that with this the artificial culture terminates, and placing the brood at once in the selected water, they leave them to their fate. They say feeding the young fish in enclosed spaces has only the value of scientific experiment, but is objectionable for practice on a large scale; to make fish into domestic creatures, and to keep trout in washing tubs, is just as foolish as to keep deer in a stable. This is illogical; for why do we take the eggs but to protect them from their numerous enemies? then why not protect the tiny fry from its enemies until it can take its own part? Others consider that the little fish, before they are turned out, should be fed in enclosed places. After the loss of the navel-bag they immediately feel the want to feed, their movements become lively, and they require more water to find more air for their breathing. All sorts of nourishments have been proposed, according to the method and experiments of Coste, Jourdier, etc., and apparatus for mincing it, to feed the fish for a shorter or longer time before turning them out. Mr. Hartmann says: "I will only remark that every process by which the young fish have other than their natural, that is, living food, given them, is under every circumstance to be rejected. Clotted blood has been forced through fine squirts, in order that it should have a worm-like appearance; small minced flesh; liver or calves' brains made into a paste by kneading with the fingers; boiled meat or bullock's heart high dried and then rubbed or grated"—and, it might have been added, the white of egg, custard, boiled rice, peas-pudding, and many fancy feeds all invented with the best intentions, and if not positively mischievous, at least good for nothing. We are not here feeding the carp tribe—which would gladly receive and gratefully get fat upon such offerings—but, as Mr. Hartmann says, a class of rapacious fish that feed almost solely upon living food. A chief evil is, as we have elsewhere stated, that all the food which is not immediately devoured when thrown in sinks to the bottom, and there forms a shiny putrefying layer, which corrupts the water, and may cause the death of the brood. The frequent removal of the putrefying stuff is of little or no use, irrespective that such stinking stuff must be injurious to every fish that may chance to swallow it. These live in freedom on the small creatures—worms, insects, etc.—which keep about the aquatic plants. In confinement a suitable food can always be procured in any quantity, by throwing into the pond the well-known green water-weed, between the roots of which innumerable water creatures live. In freedom, the smaller water insects, particularly small shrimps, afterwards insect larvæ, and worms, form their chief nutriment. The fine specimens of grayling trout and salmon trout, shown with pride at Huninguen as the result of artificial culture, do not contradict our opinion, because it is not known, or is kept secret, from how many thousand hatched fish the few shown specimens remain alive. Mr. Buckland considers that with all the numbers of ova which have been sent to Tasmania by himself and Mr. Francis Francis, if two or three remain alive as adult salmon it is a fair result. They are certainly right who consider the feeding in enclosed spaces only as a scientific experiment, but to be rejected for practice; but there is a great difference between sending creatures at once amongst their natural enemies who are waiting for them at every outlet into the main stream, and keeping them shut up in comparative bondage. A mean between the two would occur to most sensible people—plenty of room, natural food, and protection from jack, perch, and other devourers of so tender and delicious a morsel as a young salmon. But then we are met by Molin, who says, "It only requires any one to attempt to provide the proper quantity of living food when there are 30,000 or 40,000 fish to be fed, to be convinced that this is not practicable on a large scale. To those who doubt it I will say, that Coste saw four trout, each 25 millimetres long, in less than five days devour about 30,000 perch embryo." "The immense destruction which young Rhine salmon and trout can commit among the needle-like transparent brood of perch and white fish, which shoot about their ponds," says Hartmann, "I have repeatedly seen myself; but it is just these attempts at feeding which have convinced me that, without too much cost of time and labour, the natural food could be obtained for many thousands of young fish: of course this is assuming some knowledge of the lower insect world inhabiting the water. If we closely examine the water at all seasons, even in winter under the hard frozen ice covering of a lake, pool, etc., we find, even with the naked eye, an active life of all sorts of little creatures swimming about, giving quite a greenish, brownish, or reddish colouring to it." It is therefore clear that Mr. Hartmann considers there exist other more rational courses than at once to turn the young trout into deep waters to fight the battle of life so overmatched by their enemies, by whom the stream is certain to be occupied. In the food of the trout, to which allusion has been made, the naturalist will find members of the classes crustacea, brachiopoda, and entropostraca. Of the brachiopoda he finds the water-flea (*Cladocera*), with the species sida and daphnis; and astracodea, with the species cypris; the copepoda, with the species cyclops. The largest of them are somewhat more than a line long, but the smallest are hardly visible to the naked eye. The majority have only one large eye in the middle of the head, and two pair of strong feeler horns, which specially serve for their active movements. Many have bushy tails, others are tailless; with some are seen eggs lying in considerable numbers inside behind the transparent shell of the body; others carry their eggs outside in a small bag fastened to the tail; in others—the minority—there are no eggs, these are the males. The young have a different form of body from the old ones. The development and propagation of these creatures is very remarkable, and accounts for their being increased in such wonderful quantity and found everywhere. From the earliest spring only female water-fleas are seen, and these lay eggs through the whole summer, which produce fresh broods without being impregnated. This process continues with the young, which soon attain the form and size of the mother; the same process is repeated, and hence it happens that the number of the posterity of a single water-flea in the course of a warm season is so enormous as to be quite bewildering. The males appear first towards the autumn, and now the females, after preceding impregnation, lay the so-called winter eggs, which are enclosed two by two in small parcels in a tough protecting case, in which they remain, in spite of the water drying up, and frost, through the winter. These lower creatures, then, forming the first food for the fish brood, can any one say that their larder is not amply stored, provided we find the proper water and

aquatic plants for insect generation and increase? and, this admitted, is there any other excuse worth refutation for the practice of turning the fry out at once into the open deep?

We are told that Professor Jager was summoned several years ago from Vienna to the fish-culture establishment of Baron Rothschild at Silesia. The manager had informed him that out of 20,000 trout hatched, shortly after beginning to feed them with brains and blood, they all became suddenly sick, except about 200. They had become indolent, had a pallid appearance, and, in spite of the greatest care, the death of the whole brood was to be feared. After his arrival (it was in March, a covering of ice lay partly on the waters) Jager at once perceived what was wrong. He went to a ditch, and obtained, by means of a fine muslin hand-net, a large quantity of these water creatures, and threw them into the pond of the sick fish. On his return he said to Mr. Hartmann, with joy, like a doctor that has successfully performed a difficult cure, "You should have seen what a change took place in the fish at once! They swam about briskly, and snapped continually at the water-fleas, which were before their noses; only a few had already become so weak, that they could not take part in the chase with their comrades, and therefore died. But the others visibly recovered from minute to minute, their bellies were full and round, the sickly thickness of head disappeared, the pallid bodies regained the dark healthy colour, and when the next day the feeding cure was repeated, with the exception of a few deaths, the whole were cured." Fourteen days after, during which the brood was properly fed, they could be turned out with safety. The above is not alone of great importance to the fish hatcher, but to all owners of valuable trout fisheries. If the natural food of the fish is scarce—perhaps rendered so by a too great fastidiousness in the removal of weeds—the fish will get lank, bull-headed, and sluggish. Indeed, in one portion of the Wandle, the trout—which are too plentiful even were the stream full of insect food—for the want of a due supply of the latter, were, in August, 1871, as black as they would be in February, instead of being plump, fat, brilliant, and active as they ought to be.

Hartmann, commenting upon this anecdote, says it was not so much a matter of scientific experiment as that of the practice of fish culture on a large scale. And then he goes on with very many valuable facts in corroboration of his views. He maintains it is not desirable to turn out the brood immediately after the loss of the navel-bag. During the whole of the navel-bag period, which, with these noble fish, lasts as long as the embryo time (four to six weeks), the little fish lie together in thick masses, generally motionless, on the dark bottom of their breeding place, only fanning quickly with the large breast-fins, for the purpose of renewing the water necessary for their respiration. At this time they take no food at all, as they obtain it from the navel-bag itself, because this is in connection with the intestines, into which it is gradually absorbed and digested. Then the little creatures become lively, seek the light, and the places where the water is most in motion. They do the same in the stream or river; but woe to the weak which get into the strong current! many are carried away. In most years the thaw of the snow occurs just after the turning out, and then, when the brooks and streams are swollen, the fish suffer most. Many meet their death while, left to themselves, they learn to seek their food. This is the chief reason which is against turning them out immediately after the absorption of the navel-bag, and why they should be fed during their earliest youth in enclosed places until they are strong. After the disappearance of the navel-bag their requirements are different than in the previous period of development. They now require for their growth and thriving not only food, but direct daylight and water warmed by the rays of the sun; while on the previous period of development, darkness, and cold water are important essentials. For the feeding of the brood, ponds should be used which may be easily, quickly, and thoroughly superintended and kept in order. Three conditions are necessary: there must be ample space for the movements of the brood, there must be sunny and shady places, the water must circulate in them, so that an equal distribution of the food may be effected, and a crowding of the fish in particular places prevented. "In my opinion," says Mr. Hartmann, "I think the arrangement of the feeding-places should be as follows:—At a spot shaded by trees, not too far from the breeding-house, a number of basins should be laid down, which are supplied from one source. Some points must be observed in the arrangement. The water-channels which bring the different basins into communication must be so placed that the water runs through the whole equally from the first to the last. I would have oblong-shaped basins, each with a surface of about six square feet, and one foot deep; in each the water must be between six and nine inches deep. This shape has the advantage over others, because the water can be made to revolve, and the food be equally distributed. A basin of the above size can receive 5,000 fish. The feeding of the young fish should continue, at least for six or eight weeks from the time they begin to eat, from about the middle or end of February, to the middle of April."

During the first fourteen days the small water creatures above mentioned must be the sole food of the brood, and the manager must give his chief attention to procuring the sufficient quantity, as the final success depends on the fish getting over the first few weeks in a healthy condition. No one who undertakes fish culture seriously should permit himself to be deterred by the diminutiveness of the creatures mentioned, of the innumerable quantity of which in all standing waters he probably has hitherto had no conception, or by the preconceived idea they cannot be obtained in sufficient quantity. Mr. Hartmann suggests that he should make the trial with a smaller number, about 10,000 young trout, and have two or three feeding basins made. The most simple mode of collecting the food is by stretching a square piece of linen on four laths at the edge of the water, and then continually pour water from the pool with a ladle. The little animals will be retained on the cloth, and by a boy or girl continuing this work for one or two hours, a daily provision for 10,000 small trout may be obtained. After fourteen days, the end of February, or beginning of March, he may use coarser food, especially two sorts of insect larvæ, one found in running, the other in stagnant water, and a sort of water-worm. At the commencement of spring there are found everywhere in brooks and rivulets, on the blades of grass hanging in the water and driving about the water, the larvæ of the *Simulia*. Frequently a stalk is quite covered with them, to which they are attached with a fine thread. With some practice, in an hour or two as many of these plants covered with larvæ may be collected as will serve to feed 10,000 trout. These larvæ become afterwards the midges which annoy men and cattle.

SHIP-BUILDING.—X.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF WOOD AND COMPOSITE SHIPS.

Having briefly sketched the principal features of the framing of ships, we now propose to notice the chief methods of arranging their skins, which are perhaps the most important parts of the structures. Vessels have been built without framing, but every vessel, however constructed, must obviously have a water-tight skin in order that she may keep afloat. As both wood and composite ships have their skins formed by assemblages of wood planking, it will be convenient to take these two classes first, and afterwards to notice the skins of iron ships.

The planking on the outside of the frames of wood ships is usually worked in one thickness, and formed of strakes varying from, say, 8 to 12 or 14 inches in breadth; the length of the individual planks usually lying between 18 or 20 and 24 feet. The ordinary practice, it need scarcely be said, is to place the planks with their length longitudinally, so as to cross the frames at right angles. Two considerations necessarily have to be borne in mind by the ship-builder in forming the skin efficiently, viz., (1) the *arrangement* or *disposition* of the planks, and (2) their *fastenings*. We will glance at each separately, and in this we shall be aided by the sketch in Fig. 27, which shows an outside view of a portion of the planking of a wood ship.

In arranging the planking it is usual to employ either a model of the vessel, or an "expansion drawing" of the outside, and upon it to draw the lines representing the edges of the various strakes of planking. These lines would be so placed as to admit of the breadths of plank required being readily obtained, and also to allow the planks to be wrought upon the framing with

the least amount of difficulty. Next comes the very important step of placing, or "shifting" the butts of the planks, in doing which great care is required. It has already been pointed out that plain butts, such as are shown by B, B, in Fig. 27, although well calculated to transmit compressive strains along the strakes where they occur, are not at all efficient against tensile strains, and consequently it is most important to get as many passing or unbroken strakes as possible between consecutive butts lying on the same transverse section. Turning to Fig. 27, it will be observed that the butts (B) are placed upon frame-timbers, and that there are no less than three passing strakes between consecutive butts. This disposition is always made in the Government service, and generally adopted in merchant ships. It is noteworthy too that if the eye is carried from the butt of one strake to the nearest butt of the strake next below it, and so on, it is impossible to pass from butt to butt by a series of "steps" of equal length and ranging in the same direction. This fact is important, because wood shipbuilders universally disapprove of shifts of butts where "steps" occur. In the Government service the minimum distance between the nearest butts in adjacent strakes is usually six feet; in merchant ships this distance is often not more than five feet.

The outside planking of wood ships is not usually of uniform thickness from the garboards to the topsides. The thickest planking, termed "the wales," is generally placed near the main-breadth of the vessel, and in the neighbourhood of the load-line to which she floats when fully equipped. For some distance below the wales, in the Government service, it is usual to have what is called "diminishing stuff," an assemblage of planking of which the thickness is gradually diminished, until it equals that of the "bottom planking" proper, which extends between the garboards and the diminishing stuff. In merchant ships the bottom planking is generally of uniform thickness from the wales downwards; and from the wales upwards it is also uniformly thick, being generally a little thicker than the bottom planking, but not so thick as the wales. The names given to the planking above the wales in merchant ships are "sheer-strakes" and "topside planking." In wood ships of war having one or more tiers of guns, there are necessarily special assemblages of planking above the wales, bearing special names, such as "channel-wales," "sheer-strakes," etc., besides the short planks fitted between the portholes where the guns are fought; but respecting these it is not necessary to say more here.

Although Fig. 27 illustrates a common arrangement of the skin, in which planks are "fair-edged," it does not represent the only method adopted. With wood as the material employed, the builder has to consider its economical "conversion" as well as its good combination, and in providing thick oak planks for the wales he sometimes finds it advantageous to adopt one of the plans represented in Figs. 28, 29. The first of these, "top-and-butt," is more commonly used, and is especially suited to English oak planks, which, from the form of the tree, can be best provided wider at one end than at the other. It will be remarked that the broadest part of each plank is situated at one-fourth of the length from one end, and that the breadth at the butts is only about two-thirds the maximum breadth. The planks of two adjacent strakes are so fitted to one another, that their outer edges are parallel, and there is obviously no difficulty whatever in carrying out the shift of butts illustrated in Fig. 27. Greater care is required in fashioning planks worked top-and-butt, than is needed on the ordinary plan; but this is probably more than compensated for by the saving in conversion, especially with very thick plank.

The other plan illustrated in Fig. 29 is not nearly so economical in conversion as top-and-butt, nor is it so common. Its use may, in fact, be said to be almost confined to assemblages of planking where there are but few strakes, and where a good longitudinal tie is required. For example, in some line-of-battle ships, the "channel-wales" (a term requiring no explanation) and sheer-strakes have been planked on the "anchor-stock" plan; and it has been used too for some parts of the inside planking. Two strakes make up a parallel strip, as in top-and-butt, only the greatest breadths of the individual planks are here placed at the middle of their length; the butts are each about two-thirds of the maximum breadth at the middle of each plank. The symmetrical form thus produced has given the name of "anchor-stock" to the arrangement.

So far attention has been confined to the outside planking, and but little need be said respecting that worked inside the frames. The latter does not always form a complete skin like the former, but it is nevertheless of considerable importance from a structural point of view. Between the decks it is usual to work thick planking, named "clamps," "spirketting," etc.; several strakes of clamps are also usually worked in the hold directly beneath the lower deck. The remainder of the inside planking in the hold is generally made up of separate assemblages of thick "binding strakes," with the spaces between them covered by thinner planking termed "ceiling." In different vessels different plans of arranging the binding strakes are adopted. One of the most common is to have two or three thick "limber-strakes" on each side at a short distance from the keelson; and to associate these with three or four strakes of plank worked over the floor-heads, or the first-futtock heads, or over both if the vessel be of large size. In the Government service it has been customary to fit, at intervals, strong diagonal planks, named "trusses," between the lowest strake of the clamp, and the uppermost of the binding strakes upon the first-futtock head. These wood trusses have been placed at right angles to the iron plate-riders worked upon the frames, and when a second set of riders were used they were made to lie along upon the wood trusses, which thus gave them a fair bearing in the spaces intervening between the lower-deck clamps and the binding-strakes. Merchant vessels are not usually built with trusses, but the spaces between the limber-strakes, binding-strakes, and clamps are covered with thin ceiling worked longitudinally. In some cases the ceiling is placed diagonally to give greater strength. Thin ceiling is used also in the Government service, but fitted rather for protection to the timbers than for any other purpose.

In order to make the internal planking strengthen the structure as much as possible, care must be taken in shifting its butts, having respect not only to the particular assemblages of which it consists, but also to the butts of the outside planking. To strengthen the ties formed by the binding-strakes, etc., it is not uncommon to dowel them to the frames, and this connection obviously makes them more efficient against tensile strains. The contrast between such modes of giving longitudinal strength and that previously described when dealing with the framing of iron ships cannot, however, be overlooked; and in some of the modern ships of the navy iron hold-stringers (formed of plates and angle-irons) have been substituted for wood binding-strakes, in order to gain equal strength with a less cumbrous and weighty combination.

Attention will next be directed to the *fastenings* of the skin-planking of wood ships. These usually consist of through-bolts and tree-nails driven through the planking and timbers, and also through the inside planking in wake of them. Iron and copper are the materials generally used for bolts, the iron being sometimes "galvanised" or coated with zinc to preserve it from rust. Many merchant ships have only iron bolts; but copper bolts are to be preferred for at least the under-water portions, especially when the ship's bottom is sheathed with copper or mixed metal, as there is then no chance of galvanic action being set up, such as is almost certain to occur if iron bolts are used, and to lead to the rapid wasting of the bolts. The tree-nails are long circular wooden pegs, usually formed of oak or some hard wood, and driven as tightly as possible; when in place, the inner and outer ends are caulked in order to increase their holding power. The ends of the bolts are usually "clenched" upon rings which are let into the planking, so that they may have a good hold.

Various methods of combining bolts and tree-nails as fastenings to the planking have been and still are used. It would be tedious to go over these in detail, and instead of doing so three of the principal plans have been illustrated in Fig. 27. "Single fastening," which Lloyd's rules permit for planks 8 inches in width and under, consists in having either a bolt or tree-nail in each timber, adjacent fastenings coming on opposite edges of the plank. "Double fastening," used for planks exceeding 11 inches in width, consists in having two bolts or tree-nails in each timber. "Single and double fastening" is an intermediate arrangement, and is used for planks from 8 to 11 inches in width. In each mode of fastening it will be remarked that the butts of the planks are secured by two bolts, one driven through the timber upon which the butt comes—or, as it is termed, the

"butt-timber"—and the other driven through the adjacent timber. In some merchant ships only one of these bolts is driven through, the second being merely driven *into* the timber. On referring again to Fig. 27 it will be observed that while tree-nails form the bulk of the fastenings away from the butts, bolts are indicated at intervals of 5 or 6 feet in each of the methods of fastening. This is the usual arrangement in the Government service, but is not commonly adopted in the merchant service. In fact, Lloyd's rules only insist upon the butt-bolts, and leave the remainder of the fastenings to the discretion of the builder, offering him a longer term of classification as an inducement to use copper or mixed metal bolts instead of iron bolts, and to do away with a great part of the tree-nail fastenings in favour of copper bolts.

Much discussion has taken place respecting the relative merits of bolt and tree-nail fastening, and opinion is still divided on the subject. Tree-nails have the advantage of cheapness and lightness, and also appear to be less likely to force their way into the planking when the vessel is straining. The latter point has already been touched upon in an earlier paper, where it was shown that bolts being so much harder than wood must make it has been made with the work on the inside—in connection with fixing the deck beams, shelf-pieces, waterways, hooks, inside planking, etc. etc.—as enables the builder to see what additional fastenings are required. Many through-bolts are required to secure beam-knees, riders, and the various internal strengthenings, and these are so driven as to make good fastening in the outer planking also. Afterwards, when the work of "squaring off" the bottom is undertaken, other fastenings needed to complete the security of the planking are put in. It will not be forgotten that the inside planking is mainly secured by the bolts and tree-nails securing the outside planking; where additional fastenings are seen to be required, short dumps are generally employed.

The butts of the planking are confessedly weak places, the evil of which is diminished greatly by shifting them carefully, but not removed. Builders are fully alive to this fact; and, in the Government service especially, attempts have been made to strengthen the skin in wake of the butts at parts where it was considered of the greatest importance to prevent working. An example of an arrangement commonly followed in fitting the wales and thickest planking cf wood ships-of-war is given in

Fig. 28.—TOP AND BUTT.

Fig. 29.—ANCHOR STOCK.

Fig. 30.

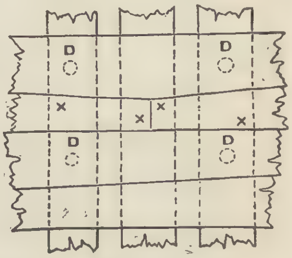
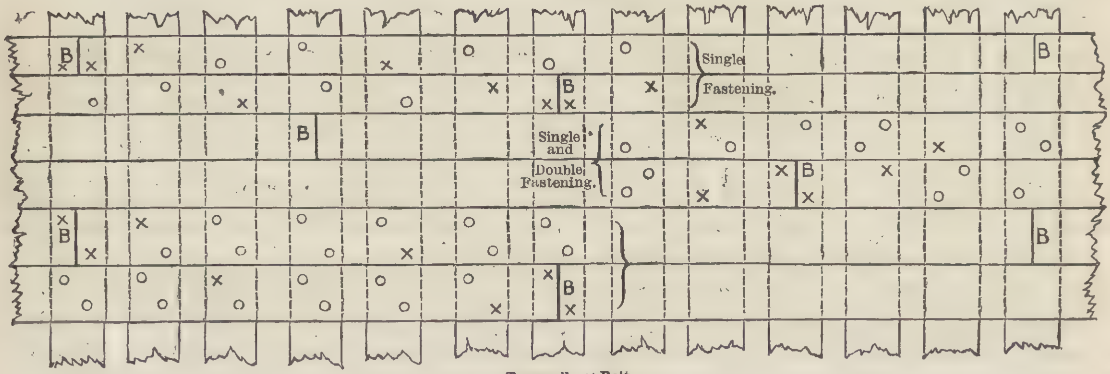


Fig. 27.



o Tree-nail. × Bolt.

yield in wake of them when the structure is subjected to tensile strains; but the tree-nails are not nearly so hard as the bolts, and are besides of greater diameter, so that the wood in wake of them would not be so likely to yield. Bolts, on the other hand, are considered to have greater holding power than tree-nails; to be more capable of resisting the strains produced by caulking the seams of the planking, during which operation tree-nails are sometimes broken off; to wound the frames less by the holes required for their passage; and to be less productive of decay in the timbers. Some builders have been so impressed with the advantages of bolt-fastening as to discontinue the use of tree-nails, substituting for them short dumps or nails driven into the timbers. This course has not been generally followed, however, and tree-nails continue to be much used.

In building a wood ship the outside planking is worked before the inside, and in the Government service it is temporarily secured to the frames by fastenings, known as "Blake's screws," which are driven in holes that afterwards receive some of the through-fastenings. In the merchant service it is common to temporarily secure the planking by means of a few bolts and tree-nails instead of using Blake's screws. These screws consist of bolts with an eye formed on one end and a wood-screw cut on the other, and they are found exceedingly useful in wood ship-building. Having thus temporarily secured the planking, the remainder of the fastenings are left undriven until such advance

Fig. 30. In the passing-strakes next above and below the butted-strake, and in the timbers on either side of that on which the butt is placed, four dowels (D, D) are fitted, in addition to the through-fastenings. The aid thus given to the butted-strake is of course indirect, but not the less valuable, especially when it is remarked that at this part of a ship working is most likely to take place by means of a change in the relative positions of adjacent planks, such as was previously referred to, as "sliding of edge on edge." The top-and-butt and the anchor-stock dispositions, in Figs. 28, 29, obviously oppose such a tendency to sliding rather more strongly than the fair-edge disposition shown in Fig. 27; but in both cases the combination of planks requires to be aided by diagonal riders. Of direct edge-fastening there is none, or next to none, in the planking of most wood ships. In some cases, it is true, edge-bolts are driven in wake of the openings between the frames and through several strakes of planking; this is a good practice, but, unfortunately, it cannot be extensively carried out, as the curvature of the ship's bottom is very considerable at many parts. The caulking in the seams supplies, by its friction on the edges of the planks, a considerable amount of resistance to sliding when the oakum is first driven; but it is certain to become slack after a short time, and then working is to be most feared. This opinion is fully borne out by experience, and few will now dispute the necessity for giving a wood ship strong diagonal riders, in order to prevent working in the skin.

THE LATHE.—VII.

By Henry Northcott.

TRAVERSE SCREW—STAR-WHEEL AND DRIVER—ARRANGEMENT FOR PERIODIC MOTION OF TRAVERSE SCREW BY EXCENTRIC ON SPINDLE.

With the automatic arrangement illustrated at Fig. 22, the working of the lathe was rendered very much less tedious, and the work produced was also of a somewhat better quality, owing to the greater regularity in the motion of the cutting tool. In turning the winch-handle, and traversing the tool by hand, it is difficult to bear always in mind that the motion of the handle must depend upon the number of rotations of the work, and not upon the time in which these rotations are made. That is to say, a small article must be rotated much more rapidly whilst being turned than an article of large diameter; and the point of the tool should move the same distance during a single rotation, whether the article be small or large, quite irrespective of the time in which the rotation is effected. In turning round the handle, therefore, the screw must be moved a certain portion of a rotation for every rotation of the work itself, and if this is not done, the surface produced upon the work by the tool is not regularly lined, as would be the case if the traverse screw had a uniform motion. The larger the diameter of the work the greater is the difficulty of producing a regular traverse by hand, and the more tedious does the work become. The difficulty can be overcome to some extent by marking a line upon the surface of the article, in a direction parallel to its axis, and by carefully moving the screw-handle a certain distance each time this line arrives at a given point in its circle of rotation. But this renders the working of the lathe still more tiresome, although the work produced is of a better quality.

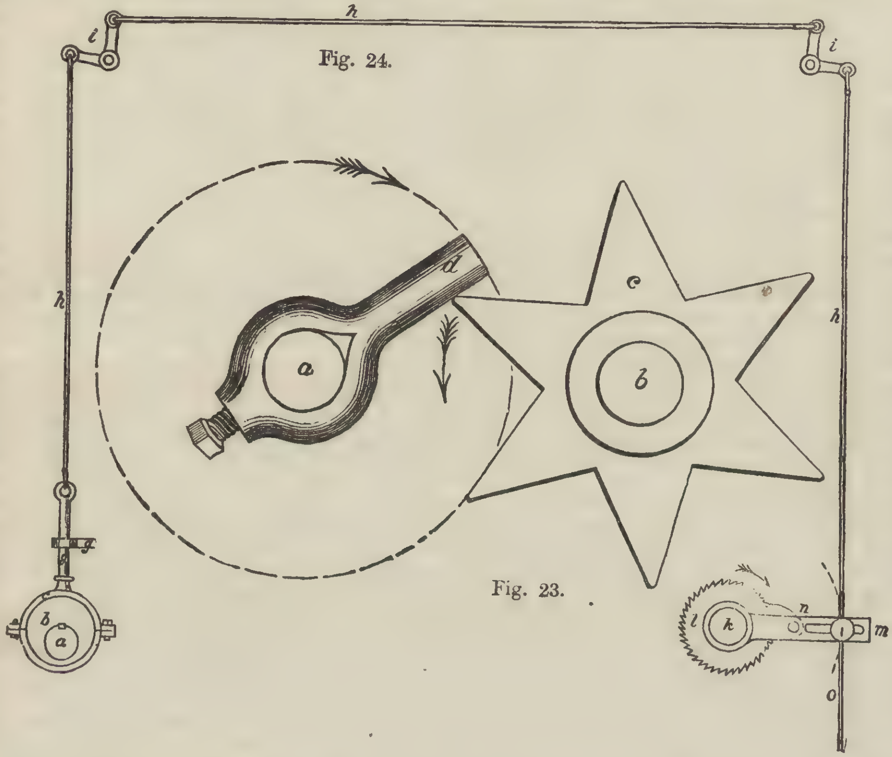


Fig. 24.

Fig. 23.

By connecting the traverse screw with the lathe-spindle, both the difficulty of getting a uniform traverse and the tedious nature of the operation are obviated, as the movements are quite automatic and synchronous.

In the arrangement last illustrated, the traverse screw is continually moving so long as the work is rotating, and the point of the tool cuts a continuous spiral line upon the work. This is as it should be; but in turning the screw round by hand, the tool is generally caused to cut as it were a ring at a time. The work produced is as good in the one case as in the other; but the continuous traverse of the tool is more mechanical than, and is to be preferred to, an intermittent motion. Generally, however, it is easier to obtain the periodic motion, than it is to connect the screw to the lathe-spindle in such a manner as to produce the continuous rotation of the former, and hence it is that in hand-lathes to which slide-rests are attached the traverse motion takes place after the completion of each cut.

One means of obtaining the feed motion is that illustrated by Fig. 23, in which a wheel shaped like a star is placed upon the end of the screw of the slide-rest, and an ordinary lathe-carrier or driver is placed upon the article between the lathe-centres, in the same vertical plane as the star-wheel. It follows from this arrangement that on the lathe being put in motion the tail of the driver in rotating comes into contact with one of the projecting arms of the star-wheel upon the traverse screw. This arm is accordingly forced onward, and the screw is moved around also, as it partakes of the motion of the star-wheel. The driver continues its course unimpeded until it comes in contact with the next arm of the star-wheel, which it also pushes forward out of its course, and the screw of the rest is again moved slightly round. This action continues so long as the lathe is in motion, and the cutting tool may thus be caused to traverse along the full length of the slide. In the figure, *a* is the article between the lathe-centres; *b* is the traverse screw of the slide-rest; *c* is the star-wheel with any number of teeth; and *d* is the tail of the carrier, fastened upon the work, and rotating with it.

The extent of traverse will depend upon many conditions, and it does not admit of much adaptation to varying circumstances. Supposing the star-wheel to have six arms, and the driver to strike once for each of its rotations, the traverse screw will evidently make one complete turn whilst the lathe makes six. By placing on the work a carrier having two equal stems or shanks, then as they will both strike the arms of the star-wheel once during each rotation of the lathe, the star-wheel will make its complete turn during three of the work, and the speed of the tool's traverse, or distance between the cuts, will consequently be double of what it would be in the previous instance. The actual distance the tool is moved by one-sixth, or one-third of a rotation of the traverse screw, depends altogether upon the pitch or fineness of the screw's own spiral, as will be fully explained hereafter.

In arranging the star-wheel and driver for use, it is necessary, as already stated, that both shall rotate in the same plane, and also that the tail of the carrier shall be within striking distance of the star-wheel, so that the carrier cannot, in any position of the star-wheel, rotate without coming into contact with one of its arms.

The best automatic mechanism for hand-lathes is probably one of those in which the periodic movement of the traverse screw is obtained through the means of an excentric on the lathe-spindle. In the last arrangement, one of the essential parts of the mechanism was placed upon the work itself, and occupied a portion of its length. This is always more or less inconvenient, and in many cases causes the star-wheel and carrier method of obtaining self-acting movements to be quite inapplicable, either from the tool having to work upon that part of the

article on which the carrier would have to be placed, or from the article to be turned being of a shape which will not allow of a carrier being placed upon it. In any case the arrangement as it stands could only be used to give motion to the tool when the latter was travelling in a direction about parallel to the line of lathe-centres. But by deriving the motion in the first place, not from any part of the work itself, but from the lathe-spindle, it can be obtained under any circumstances, and regardless of the shape of the article between the centres, which is a very great advantage.

Fig. 24 shows an overhead arrangement of this kind, in which an excentric is placed upon the lathe-spindle, generally at the left hand of the cone-pulley and gear-pinion. The motion derived from this excentric is conveyed by a cord over pulleys placed overhead, or through levers, which may or may not increase the extent of motion given by the excentric, and is then caused to actuate a lever placed upon the slide-rest screw, and move the latter round by means of a ratchet-wheel and catch. In the illustration, *a* is the lathe-spindle; *b*, the excentric placed upon it; *c*, the excentric-band or hoop encircling the excentric; *f* is a rod projecting from the excentric-band and passing through a hole larger than itself in the guide, *g*; *h* is the wire or cord fastened to the end of the excentric-rod, and passing over pulleys or through bell-cranked levers, *i*, *i*, fixed against the ceiling or the wall overhead; *k* is the slide-rest screw; *l* is the ratchet-wheel placed upon the screw and revolving with it; *m* is the ratchet-lever, which oscillates upon the slide-rest screw, and which carries a click or paul, *n*; *o* is a cord leading down to a spring or weight below.

The action of the arrangement is tolerably evident from the figure. The lathe in rotating carries the excentric around with it, and gives a reciprocating motion to the excentric-rod, and this motion is conveyed through the cords to the ratchet-lever. A downward movement of the excentric-rod causes an upward movement of the lever, and an upward movement of the lever causes a partial rotation of the ratchet-wheel and the traverse screw. The lever is brought down again by the spring or weight placed below it for that purpose. A weight is generally used, as its action is not dependent upon the position of the slide-rest, but for fast speeds the momentum of the weight consequent upon the sudden motion renders its action very imperfect. If a spring be used it requires to be attached at its lower end to some fixed part of the lathe-bed, and this is sometimes not possible, and frequently is not convenient. This method of rendering the slide-rest self-acting is infinitely to be preferred to the previous ones. The motion, it is true, is still intermittent, or periodic, but it is obtained in a very convenient manner for application. It can be communicated to the traverse screw, however the lathe may be placed, as regards angle and distance, relative to the work, and the extent of motion at each movement, or the thickness of the cut, can be regulated easily within any limits required in practice by altering the distance of the point where the cord is fastened to the ratchet-lever from the fulcrum of the lever. The further that point is from the centre or fulcrum, the less will be the motion of the ratchet-wheel and screw. If the teeth of the ratchet-wheel be tolerably fine, the thickness of the cut taken by the tool can be regulated to great nicety in this manner. The lever is generally made with a long slot or groove cut through it from near its centre to near its extremity, and the connection between the cord and the lever is made by means of a sliding screw, so that it may be only necessary to loosen that screw and slide it along the slot to the required distance from the centre to obtain any new adjustment of traverse. The mechanism is none of it in the way when not in use, and the whole of that fastened upon the traverse screw is made so that it can be removed in a piece, and replaced readily when its services are again in request.

There is another modification of the excentric motion for obtaining a self-acting traverse, in which the motion of the excentric is not taken overhead and brought down to the lever, but is communicated to a small shaft placed along the front of the lathe-bed, and from this shaft it is taken off for moving the ratchet. In this the excentric gives a rocking motion to the shaft through a lever and connecting-rod, and by the same means the rocking motion of the shaft is communicated to the lever. This latter lever, however, is made so that it can be moved anywhere along the rocking-shaft, and placed just under the ratchet-lever whenever the slide-rest may be placed upon the lathe-bed. The rocking-shaft may be neater than the overhead cord and levers, but it is not quite so convenient.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXV.—ARCHIMEDES, THE GEOMETRICIAN.

BY JAMES GRANT.

THIS famous philosopher, who invented a machine of glass which faithfully represented the motion of all the heavenly bodies, who constructed the great ship of Hiero, and conducted the defence of his native city against the Romans, was born at Syracuse, in Sicily, where his memory is still venerated, somewhere about the year 287 B.C. That he was a man of humble or obscure birth, which Cicero would seem to indicate, by the sentence, "Ex eadem urbe *humilem homuncionem* a pulvere et radio excitabo, qui multis annis post fuit, Archimedem," is not the fact, as he was a near relative as well as the friend of Hiero II., who was descended from the family of Gelon, who formerly reigned in Syracuse, and who, after being appointed captain-general by the Syracusans, was soon after elected their king. Under the tyrant Dionysius, the city had then risen to great power and splendour, and was able to maintain a force consisting of 10,000 cavalry, 100,000 infantry, and 400 galleys for war.

The mathematical genius of Archimedes set him with such excellence in the view of the old classic world in which he lived, that he became the honour of his age, and was deemed "the prince of mathematicians," being to the ancients what Sir Isaac Newton is to the moderns. So deeply did he think, that at times he became lost in a kind of reverie, during which it is said he would study for days and nights without food. He was equally skilled in all the sciences—astronomy, geometry, mechanics, hydrostatics, optics, etc.—and made many great inventions.

Among these is the pumping screw which still bears his name; a machine for launching and for raising ships in the air; and the celebrated burning glasses, which were deemed fabulous by the moderns, till Buffon made the experiment by four hundred small mirrors so disposed that when the rays from them all fell on a certain point, he melted lead at 120 feet, and set fire to a haystack at a much greater distance. Many of the treatises written by Archimedes are still extant, especially those "De sphœræ, etc., cylindro, circuli dimensio, de lineis spiralibus, de quadratura paraboles, de numero arenæ," etc., the best edition of which is that of David Rivaltius, fol., Paris, 1615.

It is related that once when King Hiero was examining with admiration some of the mechanical contrivances of Archimedes, the latter said, "Give me but a place to fix a sufficient machine upon, and I will undertake to move the earth itself!"

By a method which, however curious, is well known to every modern hydrostatician, he detected the deceit which had been practised by a workman whom King Hiero had employed to make him a crown of gold. As it was to be an offering to the gods, Hiero wished it to be one of great value and purity, and for this end weighed out the precious metal to the artificer. After some time the latter brought the crown home, and it was found to be of full weight; but it was ere long discovered or suspected that a part of the gold had been appropriated, and silver substituted in its place. Indignant at the imposition, Hiero desired Archimedes to take into his consideration the means by which such a fraud could be with certainty discovered. While engaged in the solution of this matter, he happened to go into the bath, where, observing that a quantity of water overflowed equal to the bulk of his body, it presently occurred to him that the king's question might be answered by a similar method; and hurrying to him, "I have found it!" said Archimedes; "I have found it!"

He then made two masses each of the same weight as the crown, one of gold and the other of silver; this being done, he filled a vessel with water to the brim, and put the silver mass into it, upon which a quantity of water overflowed equal to the bulk of the mass; then taking the mass of silver out, he filled up the vessel again, measuring exactly the water which he put in; this showed him what measure of water answered to a certain quantity of silver. He then tried the gold in the same manner, and found that it caused a less quantity of water to over-

flow, the gold being less in bulk than the silver, though of the same weight. He then filled the vessel a third time, and putting in the crown itself, he found that it caused more water to overflow than the golden mass of the same weight, but less than the silver one; so that, finding its bulk between the two masses of gold and silver, and that in certain known proportions, he was able to compute the real quantities of gold and silver in the crown, and thus manifestly discovered the fraud.

To illustrate to Hiero the effects and power of motion, he selected one of the greatest galleys in the port of Syracuse, and had it beached, with labour and by the hands of many men. He then ordered its usual lading to be put on board, and also as many soldiers as it would hold. Then placing himself at some distance, and sitting at his ease, without trouble or in the least exerting his strength, by simply turning with his hand the end of a machine which had been provided with ropes and pulleys, "he drew the galley along the dry land with as much ease and as upright as if it swam on the water."

Hiero, his friend and kinsman, was so astonished by this contrivance, and the power it depicted, that he solicited Archimedes to construct battering engines and other machines for sieges and attacks, and for the defence of walled cities. Hiero, who was great and magnificent in all his ideas, especially in the erection of temples, arsenals, and palaces, had a galley built by Archimedes; the construction of it lasted a whole year, and the king passed entire days among the workmen to animate them by his presence. The barest description of this great ship would be far beyond our limits. Suffice it that she had three masts, was coppered, and furnished with twenty benches of oars. Inside were three galleries, one for the soldiers alone. The poop was the kitchen, the floors of the apartment being laid with mosaics, depicting scenes from the "Iliad" of Homer. On deck were olives and vines, planted in pots, and watered by pipes of hardened clay. The windows were thin sheets of fine ivory. She had bathing coppers for holding water; one held 250 quarts, and a tank or reservoir at the forecastle held 100,000 quarts. All round this ship outside were a row of atlases of six cubits, *i.e.*, nine feet high, placed equidistant. She had eight towers for archers and slingers, and an engine (constructed by Archimedes) which flung stones of three hundred-weight. All round her were irons for grappling the galleys of an enemy. Her hold was extremely deep, but one man sufficed to keep it clear of water "with a machine made in the nature of a *screw* by Archimedes." When finished, no port in Sicily could hold this great ship, so, as there was a scarcity in Egypt, she was laden with grain and sent as a present to Ptolemy Philadelphus. Such is the description given of her by Athenæus, who unfortunately left no record of her dimensions.

When Marcellus, the Roman consul, besieged Syracuse, the inventions of Archimedes enabled the citizens to protract the defence for three years; and so sensible was the consul of the value of the philosopher, that he gave strict orders, in the event of the town being stormed, that his soldiers "were not to hurt Archimedes, and he even offered a reward to those who should bring him alive and safe into his presence."

To Appius he assigned the command of the land forces, and reserved to himself that of the fleet, which consisted of sixty galleys, each having five benches of oars, armed with soldiers, chiefly archers and slingers to scour the walls. On their decks were many of the cumbrous battering machines used prior to the invention of cannon. Finding themselves assailed by sea as well as land, the Syracusans were filled with considerable trepidation; and but for Archimedes, to whom the defence was assigned by Hiero, their resistance would have been small. Machines constructed by him hurled upon the Roman infantry showers of darts and stones that were of enormous size, and which went whizzing through the air with a startling sound. They beat down or dashed to pieces all that came in their way, and occasioned the greatest disorder in the close ranks of the legions.

Marcellus fared no better by sea. The balistæ and catapultæ of Archimedes had all longer ranges than those of the Romans, and baffled the attempts of their best engineers. Nor were these their greatest danger. "Archimedes had placed lofty and strong machines behind the walls, which suddenly letting fall vast beams with an immense weight at the end of them, upon the ships, crushed and sunk them to the bottom. Besides this, he caused an iron grapple to be let out by a chain; the person who guided the machine having caught hold of the prow of a ship with this hook, by means of a lever-weight let down within the walls, it was lifted up and set on its stern, and then by letting go the chain either by wheel or pulley, it was let fall again with its whole weight either on its head or side, and often entirely sunk. At other times his machines dragged the ship towards the shore by cords and hooks, and after having made it *whirl about a great while*, dashed it to pieces against the rocks below the walls, destroying all within it. Galleys frequently seized and suspended in the air, were whirled about with rapidity, exhibiting a dreadful sight to the spectators, after which they were permitted to fall into the sea, when they sank to the bottom with all that were in them."

Archimedes also constructed loopholes in the walls; at these he placed scorpions, machines in the nature of crossbows for discharging darts, and Marcellus began to be at a loss what to do. "Shall we persist," said he to his soldiers and engineers, "in making war on this Briareus of a geometrician, who treats my galleys and sambucæ so roughly? He infinitely exceeds the fabled giants with their hundred hands, in his perpetual and surprising discharges upon us!"

The Romans at length became so intimidated that if they saw upon the walls "only a small cord or a little piece of wood," they would scatter and break their ranks, crying out that Archimedes was about to discharge some dreadful machine upon them; hence Marcellus soon had to convert the siege into a blockade, during which part of his fleet was destroyed by fire.

"A burning glass is spoken of as the means by which Archimedes is said to have burnt part of the Roman fleet," says Rollin. "That must have been an extraordinary invention; but as no ancient author mentions it, it is perhaps a modern tradition without any foundation. Burning glasses were known to antiquity, but not of that kind, which, indeed, seems impracticable."

Syracuse at present has two harbours, the smallest on the north-east of Ortygia. Tradition still shows here the exact site of the house of Archimedes, and also of the tower from whence he is said to have set fire to the Roman galleys by his burning glass—a concave speculum, with a focus of enormous length—as their vessels lay between him and the sun, in a direct line at noon.

Syracuse at last fell by storm, and Archimedes perished. The philosopher was so deeply immersed in some problem that he knew not that the town was taken till the sword of a Roman soldier was at his breast. Plutarch says the latter commanded him to follow him to Marcellus, and on Archimedes refusing till his problem was solved, he was instantly slain. Livy says he was slain by a soldier who did not know him, as he was drawing a diagram in the dust. Marcellus sorrowed for this catastrophe, and interred him with honour under a tomb on which were carved a cylinder and sphere. This event occurred in the 143rd Olympiad, or about 212 years B.C.

Long subsequently, when Cicero was quæstor in Sicily, curiosity prompted him to search for the tomb of Archimedes, and, after many efforts, he tells us, that among a great many tombs without the gate of the city, facing Agrigentum, there was found a pillar almost entirely covered by thorns and brambles, but thereon were the sphere and cylinder! The inscription was still legible, though partly obliterated by time, and Cicero ordered the place to be cleared and the tomb respected.

Excavated from a bed of native rock, the face of which, naturally projecting, is shaped about the opening into a rude Doric front, with rich pilasters and a pediment, the tomb of the great geometrician may still be seen at Syracuse, where at this hour the walls of the Conversazione Room are covered with pictures of his mechanical exploits.

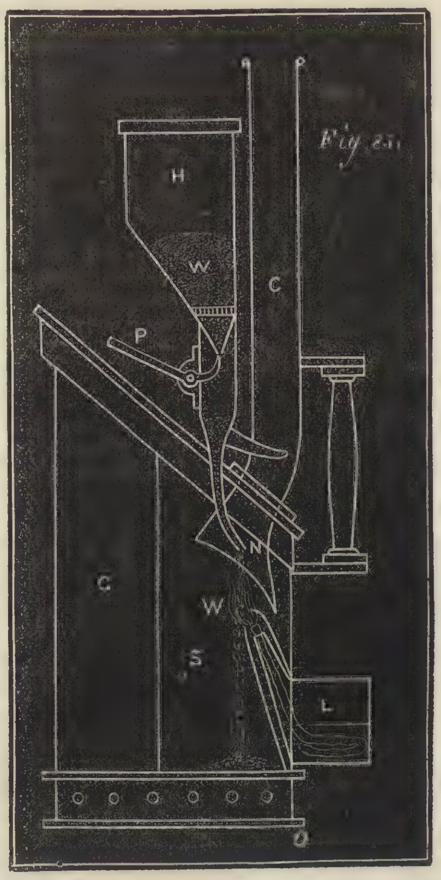
OPTICAL INSTRUMENTS.—XIX.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

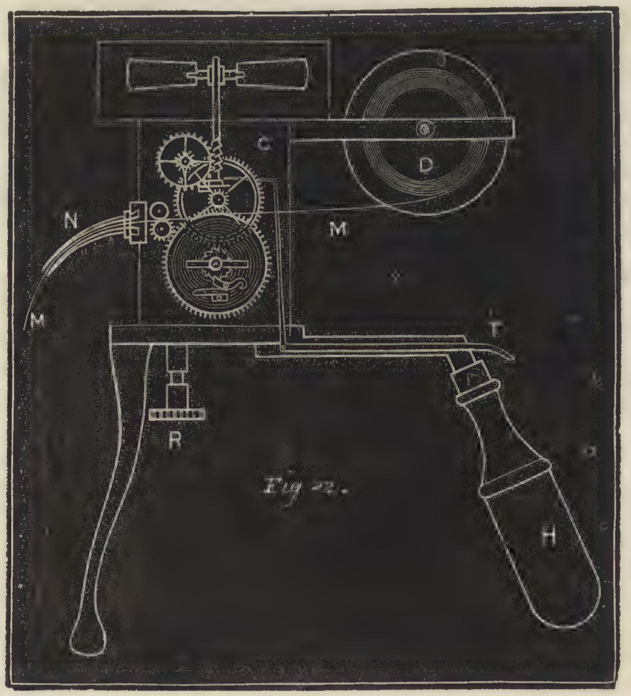
Magnesium Light.—Next in convenience to the lights previously described is that produced by the combustion of the metal magnesium, which for intensity is almost equal to that of the electric arc, but from its flickering nature, and the large amount of magnesia vapour given off during the operation, its application for long-continued use is as yet impracticable; moreover, it is not so purely white as either the electric or lime lights, being characterised by a bluish tint that reminds

one of moonlight. As, however, this source of light is rich in actinic or chemically active rays, it is peculiarly well adapted for photographic operations, where a beam of light of a few minutes' duration is usually sufficient. The magnesium light has been recommended by some persons for magic lantern purposes, but no practised exhibitor would endorse such advice, for the reasons that a cumbrous coil or length of chimney-piping is required to carry the magnesia vapour from the lantern to a fireplace, or some other suitable up-draught, probably separated from each other by a distance of many feet; and, secondly, because whether we use single or multiple strands of magnesium wire or ribbon during the act of combustion, these twist into a corkscrew-like spiral, that causes the point of light not only to vary as to position but also as to brilliancy, till this oxidised part falls away of its own accord, or is broken away mechanically. Were it not for these drawbacks, which as yet have not been surmounted, this source of light would strongly recommend itself to the physical investigator and demonstrator, as the preparation of the magnesium light apparatus is of the simplest character, and involves no bulky or expensive appliances or accessories, as will be seen by the description of the apparatus and its manipulation presently to be given. The metal magnesium, discovered in microscopic quantities by Sir Humphry Davy in 1808, during his experiments on the electric deposition of alkaline metals on the electrodes of a voltaic battery, has, through the progressive investigations of Bussy, Deville and Caron, Bunsen and Roscoe, and Sonstadt, in recent years, been produced on a commercial scale that allows of this once very costly metal being supplied at somewhat over double the cost of silver, though it must be remembered that an ounce of magnesium is six times the bulk of an ounce of silver. In the early days of its manufacture on a commercial scale, magnesium was supplied in the form of wire, but more recently in that of a flat narrow ribbon, which is more convenient for manipulation; it is also sold in the form of powder or filings. Magnesium ignites at the temperature at which glass melts, and, besides giving off clouds of vapour, leaves a white ash, which is pure magnesia. It has been determined, photometrically, that a very fine magnesium wire emits a light equal to that given by seventy-four stearine candles of five to the pound. It may here be remarked that zinc presents very much the same photogenic characteristics as magnesium, and is used as an alloy to allow of magnesium ribbon being sold at a cheaper rate than pure magnesium would admit of, without detracting



from its efficiency for light-giving purposes. There are two arrangements for burning magnesium: one for the delivery of this body in the form of a ribbon, the other in the state of powder when mixed with fine silver sand. The best lamp constructed on the first principle is that patented by Mr. Solomon, of Red Lion Square, and is that generally adopted by operators. The other arrangement is that invented and patented by the late Mr. Richard Larkin.

Solomon's Magnesium Lamp is shown in Fig. 82. The mechanism consists of a narrow drum enclosed between two discs of metal, D, capable of holding one ounce of magnesium ribbon when coiled up like a watch-spring, M, which rotates freely on an axis supported by arms that clamp on to a metal case that holds a driving-clock, C. This clock consists of a train of wheels which can be set in motion by a clock-spring, and in turn these rotate, by means of a connecting cog-wheel, a pair of delivery-rollers, between which the end of the magnesium ribbon is introduced, and by their action is passed through the curved nozzle, N, at which point the magnesium is ignited by means of a spirit-lamp. The ribbon should be paid out at the rate of combustion, viz., one yard in three minutes, and the clockwork is adjusted for this, by the suitable inclination of two regulating fans, F. The clockwork is wound up by a key attached to the side of the metal case, and is set in motion or stopped by raising or depressing a lever, T. This part of the apparatus is supported on a tripod stand, of which one leg forms a handle, H, by which it can be carried, or the light directed to any desired point. This lamp is charged by unscrewing a nut that clamps the drum, D, to its supports, and allows of its removal. One side-plate of the drum is then unscrewed, a coil of magnesium ribbon is placed over the drum, the tape that confines it cut and removed, and the inner end of the ribbon twisted and fixed to the drum itself. The side-plate is then replaced, and the drum fitted between its supports, care being taken that the ribbon is placed so that it unwinds from *the bottom*, as shown in Fig. 82, for if placed in reversed position, so that it unwinds from the top, it is liable to drag and get displaced. When the clockwork is in motion, introduce the end of the ribbon through an orifice in the back of the clock-case, press it forward till it is gripped by the delivery-rollers and is passed through the end of the nozzle, when the motion must be stopped by the lever, T, till such time as the light is to be brought into operation. This is the arrangement in its simplest form, but it may be made to deliver two or four ribbons. The clockwork may be arranged to run for

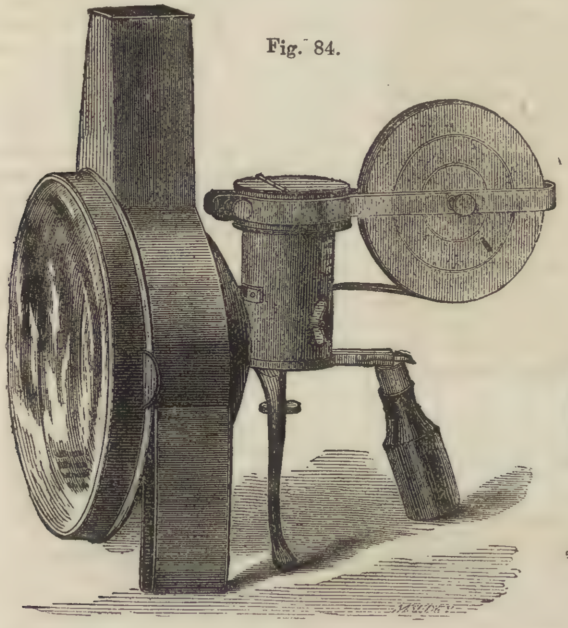


a few minutes, for fifteen minutes, or for an hour, according to requirement; for short exposures, as in photographing sculpture, portraiture, copying pictures, etc.; or for longer exposures, when buildings, caverns, mines, etc., have to be lighted up; or the requirements of theatrical effect, military and naval signalling, or fishing or diving purposes. The delivery apparatus may be fitted with a silvered concave mirror, for concentrated light, or a flat reflector for diffused light, as shown in Fig. 83, for indoor use; or it may be fitted with a glass front and a chimney, as shown in Fig. 84, for outdoor use, or in places where it is desirable to carry off the magnesia vapour. It is very convenient to have an ashpan filled with water placed a few inches below the nozzle, into which the magnesia ash falls, and, moreover, this aids in freeing the ribbon from its spiral excrescence that is so detrimental to the more extensive applicability of magnesium ribbon lamps.

Larkin's Magnesium Lamp is shown in Fig. 85; it consists of a funnel-shaped hopper, H, in which is placed the mixture of magnesium powder and silver sand, W, the latter being added in such proportion as to assist a steady flow of the combustible metal, and in a divided state, so as to present a spirit-lamp flame in the best condition for perfect and rapid combustion. The bottom of this hopper is floored by a wire-gauze sieve, and closed by a conical plug fixed at the end of a pivoted arm, P, that, acting like a trigger, allows of the end of the hopper, H, being opened at pleasure, and the powder dropping down and out by a nozzle, N, that is placed directly over *the centre of the flame* of a spirit-lamp, L, the wick of which is placed out of the range of the falling powder. Both the hopper, H, and the spirit-lamp, L, are affixed to the metal framework of a closed lantern, S, the front of which is glazed with a sheet of curved glass, G. A tubular chimney, C, is fixed to the top of the lantern to carry off the fumes, and a conical metal shield springs from the bottom of the framework to guard the wick of the spirit-lamp. A stiff loop of wire is fitted over the nozzle-tube, and by a lever action scrapes off any incrustation of magnesia that may be deposited on the nozzle, N, in a way to impede the proper flow of the powder through the flame. The continuance of the flame depends upon the opening and shutting of the conical valve, P, or the exhaustion of the charge of magnesium powder placed in the hopper. This form of lamp is best suited for signalling purposes, as well as for photographic and illuminating requirements. A larger form of this arrangement was employed at the Nottingham meeting of the British Association for lighting up a large refreshment tent and a garden attached thereto, two lamps being sufficient for the purpose.

Magnesium Photogen.—For certain photographic operations, such as taking portraits of the living or dead, by means of small cameras and lenses, in rooms where sufficient sunlight is not attainable, and especially in *photo-micrography* (photographic delineation or enlargement of microscopic objects) or *micro-photography* (production of minute photographs), the method of producing the requisite amount of actinic effect upon the prepared surface by means of a definite charge of light-producing material strongly recommends itself. This method is best carried out by mixing, shortly before use, 72 parts of magnesium powder with 122 parts of dry chlorate of potash in powder, and determining by experiment how many grains of this mixture will produce the necessary action, by a given photographic process, with the particular kind of apparatus employed. The determined quantity may be termed "the standard photogenic charge," and more or less than this may be used according to the actinic or non-actinic character of the object to be photographed by artificial light. For instance, in taking photo-micrographs, if the object is of a blue or violet tint, less—if yellow or red, more—than the standard charge may be used. The required quantity of "magnesium photogen" should be piled in a conical heap on a little metal saucer mounted on a

Fig. 84.



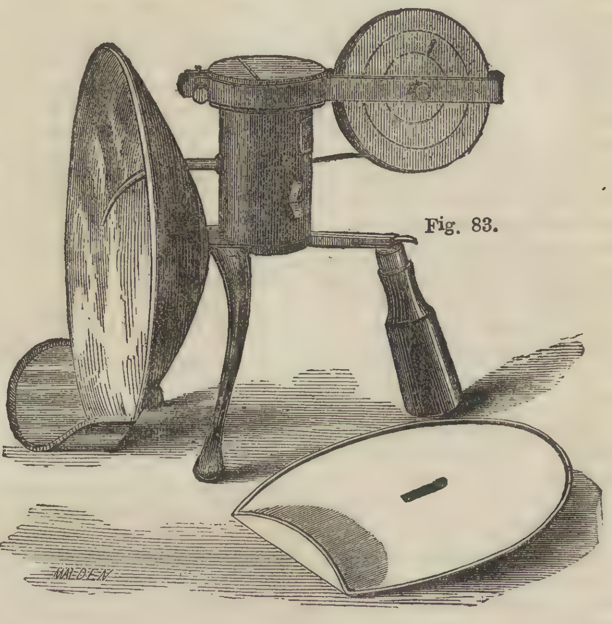


Fig. 83.

telescopic stand, placed in the focus of a parabolic or concave mirror adjusted to the optical axis of the apparatus employed, and be lighted with a lucifer match when all is in arrangement for the exposure. If working with photographic dry plates, it is a good plan to use three in succession, one being exposed to the full standard charge, the others to the minimum and maximum charges; between the three, and by judicious development, a good result should be attained. Magnesium powder may be obtained at half the price of the ribbon, and whatever arrangement is adopted, a photographic impression may be produced on a prepared surface for a cost that does not exceed twopence, with a source of light that is little inferior in actinic power to the sun itself, and is ever at command, night or day. Magnesium powder is now extensively used in the manufacture of fireworks, as may be noted by those who have seen the magnificent pyrotechnic displays at the Crystal Palace.

Photography and the magnesium light may be taken conjointly as an admirable example of the progress of science and scientific knowledge during the nineteenth century. At its commencement we were indebted entirely to the eye and hand of man for the pictorial representation of any object. The art of photography was then discovered, by which an accurate picture of an object was obtained by means of the sun's rays reflected from its surface; and now the brilliant magnesium light renders us independent even of the sun itself for the production of pictures by the agency of light.

FISH CULTURE.—VIII.

By Greville Fennell.

PROPER NATURAL FOODS FOR YOUNG FISH—FENCE MONTHS —METHOD OF TAKING EGGS FROM SALMON—THE WATER-OUZEL.

While speaking of proper foods for newly-hatched fish, we may remark that another excellent natural food at this time is the larvæ of the common gnat (*Culex pipiens*), which also hatch out in the water, but, contrary to the *Simulia*, only in stagnant pools filled with rotting plants. The *Simulia* lay their eggs crawling down to the stalks of the plants in the water. Their development is very rapid, and in every ditch and flooded meadow, in every puddle, the larvæ will be found throughout the year in quantities. It is advisable to make some pools for breeding gnats' larvæ so arranged near the feeding ponds that the food may be taken direct. Another very good food is the fresh-water worm (*Nais*), very thin and red in colour; these either swim about in stagnant waters or lie in the mud in masses, from which they may be collected with a narrow mesh wire net which is distended round a strong ring. Fed on these water larvæ and worms, the fish grow rapidly, and in the last weeks the young fish should be supplied with plenty of tadpoles, the larvæ of toads and frogs.

The great grass frog (*Rana temporaria*) lays its eggs in March. At the end of that month and beginning of April, the tadpoles are found everywhere in stagnant water. If at the proper time the great shining lumps of spawn, of which whole barrowsful can be collected in a few hours from adjacent waters, be brought to a small pond shaded from the sun, and provided with decaying plants, near the establishment, in a few days the tadpoles will hatch out, and there will be an ample supply of food for the rest of the feeding-time. As it will occur that some of the young fish, being better feeders, will be double the size of others, it is advisable to place them in a separate basin, otherwise they will take too much food from the rest, and prevent their development.

An element in the success of the cheapening of salmon is almost essentially a fishmonger's question. As with coal-owners and all large monopolists, their interest is to keep up the price, and this they do to a certain assured extent by the assistance of the telegraph, and a well-considered system of agencies which directs the fish only to those several markets where a demand sufficient to ensure the maximum price exists, the saleman and tacksman both combining to keep back the salmon in the cruves in their natural element, or in ice on land until such times as the inducement to transit arrives at a fixed and agreed standard. This is now so well known that no longer is any secrecy involved in the matter, and it appears fair enough between consumer and producer; but a bountiful Providence frequently defeats even the best of man's schemes, and in times of great plenty the desire for high prices is merged in the aggregate returns; and this would be still more the case if we could remove all obstacles to the breeding of salmon, and thus make the very weight of the takes force out of view the present selfish ends of the tacksman, who would still obtain the same profits, but not at the expense, so to speak, of the public, for there is even a minimum to be reached in the price of salmon below which it can scarcely go, unless close to the scenes of its capture.

While upon this point we may state from high authority that a plan is in contemplation to make fish-salesmen take out a licence if they sell salmon, as for selling game. Thus, although the annual impost would not be large, and scarcely felt by the dealer, it would produce a great income, which should be devoted towards building salmon ladders over weirs and other obstructions, and providing funds for paying watchers during the winter. This would tend materially to multiply the number of salmon, and enable the commissioners who are now poor in funds to carry out preservation with greater strictness and effect.

Fish culture being a subject which has occupied many volumes and yet has not been exhausted, some allowance must be made here for all omissions and shortcomings. We have, however, done our best to give as much detail of the processes pursued and as general a view of the present state of fish culture in this and other countries as our space would permit. Those who would follow up the subject yet closer should refer, besides the works of which we have made mention, to "Historique sur Établissement de Pisciculture de Huningue," Strasburg, published by Berger-Levault, 1862; "The Salmon Fisheries of England, 1868. From authentic information obtained for the House of Commons. To which is added valuable and exclusive information extracted from the Reports of the Commissioners of Fisheries in France, America, Norway, and Russia. By Thomas Ashworth, Esq." London: Longman, Green, and Co. Bath: William Lewis, "Directory" Office.

No man who aspires to the character of an angler would ever destroy the fry of salmon or take any migratory species that has not been down once to the sea, and owners of fisheries cannot be too vigilant in putting down all unlawful nets or engines, as these instruments of wholesale slaughter do more harm in a few hours than the whole of the fair fishing put together.

The trout grows remarkably fast in the Thames, and is tolerably good food when in its prime. But angling is permitted far too early for this valuable fish, it being often captured in March, when, after spawning, its appetite being voracious, it is made an easy prey by the impatient angler. This thoughtlessness of the fisher cannot be too strongly denounced. All remonstrance, however, appears in vain, for as long ago as 1840 a writer upon angling literature used very strong terms with a view of putting a stop to the system. "Thames anglers," he said, "begin to fish too early in the season: by spinning a minnow or bleak in the month of March, they may take a ten-pounder, which is not uncommon, and then they boast of having captured a fine fish, whereas, in fact, it is only fit to be thrown away, being full of worms and flabby flesh. Were such a fish left for three months longer, it would not only have increased in weight, but it would have been worth something considerable, as it would have been in season. In taking a trout at that time, there is neither art nor science, the fish being still so weak from spawning—for large fish spawn very late—that it has not the power to contend against the rod and line, which it would have had in June."

Fence months, in all waters whatever, should be rigidly observed. The strictest attention and watchfulness is then required, not only to the parent fish, but the brood, for it is at that time the young of salmon may be taken by the most simple contrivances, and pike more particularly—the nature of which is to run up ditches and shallow tributaries to spawn—will then allow themselves to be snared by the wire of the most stupid plough-boy. The destruction of under-sized fish in the Thames has very properly received the attention of the officers and water-bailiffs of the Thames Angling Protection Society, and nothing can serve better to demonstrate the fact that the small fish of the present year are the takeable and appreciable stock of the next, than the marked increase in size and weight in 1871 over that of last year (1870), the fish in the interim having been protected by extra vigilance, and any infringement of the bye-laws having been at once followed by the punishment of the delinquents. Mr. Boccius, when writing some years ago upon this point, observed that not only with regard to trout and salmon was the want of a proper system of protection forcibly felt, but this same shield of protection is wanted in all rivers for all other fresh-water fish; for were the artificial principle and protective arrangements extended to them, their increase would be enormous. In that part of the Colne, for example, which this gentleman laid down and attended to, even roach grew to the great weight of from one and a half to two pounds in their fourth season, and this weight was almost unprecedented elsewhere. This shows at once what protection, which means constant and methodical watchfulness, will do for fisheries; and that fisheries, like farms, when looked after systematically, will flourish, but when neglected, will fail.

Where trout and grayling are the objects of care, the streams should be dragged two or three times in a season to get rid of the coarse fish and give room to the rising brood of the better class. Indeed, all streams are the better for an occasional clearance of the large pike, even in pike preserves, and if they are not immediately needed for the table they should be kept in stews and fed upon roach, dace, and bream, which in comparison are worthless.

We are reminded in looking through our preceding papers, that although we have spoken of the method of dealing with a trout by holding it when full of spawn in the attitude shown in Fig. 6 (Vol. II., page 353), when the ova, if ripe, will drop down in a mass towards the vent, the operator would find it somewhat

difficult to hold a salmon in that position. Mr. Francis Francis tells us that, with a large and vigorous salmon, it has required at least three men to hold it, and that then the task is not easy. "I have known a salmon," he writes, "in its struggles send pots, pans, water, and ova flying with one dash of his tail. The softness of the belly is the best test here. In grayling the belly is less soft, the fish being more of a hard and scaly nature generally. A slight pressure, however, if grayling or salmon or trout be at all ripe, will usually be sufficient to extrude two or three eggs, when the fish should be carefully put up until all preliminaries are prepared for operation. How the fish are to be kept alive depends entirely upon the conveniences at hand. In some rivers a little pool can often be made at the river's side; in others, pails or even washing-trays are used. A salmon can be tailed—that is, tied up—by means of a cord, a slip knot being passed over the tail. A male or female fish being secured, obtain one of the other sex as soon as possible." Mr. Francis adds "that it is always as well, if they can be had without difficulty, to retain two males to one ripe female, in case of a scarcity of milt."

It must still be understood that we are now treating of salmon—not trout or manageable fish. "The requisites for spawning the salmon properly are, first, a shallow open dish, with a lift to it (this dish should not be less than twelve or thirteen inches square at the least); a large jug for fresh water; and a tin can, with a perforated lid, to carry the ova in (this should be a can capable of holding at least a gallon of water). First half fill the dish with clean water; take the female, one person holding the head and another the tail and if necessary a third steadying the body. If the head be held between the knees, a better hold will be got; and if a *dry* cloth be used to hold the fish, there will be less chance of her slipping. Now, the fish being held with her tail downwards and the body rather sideways, or with the belly a little towards the operator, the vent being as closely over the water in the tin dish as may be convenient, the manipulator should, steadying the fish with one hand, compress the body with the other, passing the finger and thumb upon either side with a gentle pressure from the thorax down to the vent. This pressure, be it remarked, must not be harder than is sufficient to expel the eggs without difficulty. If the fish does not give up her roe, no force must be used; but lay her aside on the grass, or even in the water, for a few minutes, when, perhaps, she may be more easily persuaded. If, however, she declines, she is not quite ripe enough; and if you have the means of keeping her for twenty-four hours, or forty-eight hours, it will be advisable to do so. But, I repeat, *no force must be employed.*"

It may not be out of place here to remark that, in proof of the practical, not to say commercial, shape which pisciculture has taken, an establishment has been opened at the Trouldale Fishery, near Keswick, Cumberland, under the management of Messrs. Joseph J. Armistead and John Parnaby, for the distribution of ova of various fish throughout the country. But to show to what an extent Messrs. Francis Francis, Buckland, Youell, Ponder, and others have been unselfishly inspired by their gratuitous aid to fish culture, we quote from the tariff of this firm:—"American trout fry, £100 per 1,000; black bass fry, £100 per 1,000; Canadian *fresh-water* salmon trout fry, £100 per 1,000; trout ova, 50s. per 1,000; and trout fry, 60s. per 1,000." Let us hope that there will yet be a more substantial recognition of the services of these gentlemen, from Tasmania and elsewhere, than their most important labours have hitherto elicited.

Let us say one word at parting for the water-ouzel, which has most wrongly been classed amongst the enemies of fish ova. It is strange to say that this prejudice still obtains, realising the old axiom of "Give a dog a bad name and hang him." Yet the Zoological Society, so far back as 1863—many years, as events succeed each other now—having fairly put the water-ouzel upon its trial as a notorious destroyer of fish spawn, the first verdict was "Not proven." This being the form of a Scotch verdict, an English water-ouzel was entitled to enter a demurrer. We are therefore not surprised to learn that a distinguished ornithologist objected to it, and that the jury ultimately returned their verdict thus: "Water-ouzel *fully* acquitted of the charge of eating fish spawn." The fact is the water-ouzel frequents the spawning-beds in order to prey upon the insects which feed on the ova of the fish; so that in our merciless ignorance we have been killing a piscicultural friend every time we shot a water-ouzel—just as we believe the farmer hangs a friend every time he traps a mole, or drives a host of well-wishers away by employing a boy to frighten the rooks from eating the larva of the cockchafers and daddy-long-legs.

The elastic toughness of the ova has been before observed upon, but it should be pointed out that this considerably facilitates the transport of fish ova for the purposes of pisciculture; and experience has demonstrated, principally through the perseverance and judgment of Mr. Youll, that they can be safely transported for any distance which can be travelled, either by land or water, in the time during which the ova naturally remain unhatched. There is one simple rule which must, however, be insisted upon—never to attempt the removal of ova till the eyes of the fish are plainly seen in the egg.

In reference to the food of fish, and the necessity to encourage the growth and increase of such food as fish must profit upon and delight in, Mr. Francis, in his "Fish Culture," has some highly suggestive and important observations. "We should know what kind of food suits our various fish best, and what conditions best produce that food, and how these conditions are best to be cultivated, so that such food may be self-producing." The chapter from which we quote, on the food and its production, demonstrates in a very interesting manner how great is our ignorance of this department of knowledge. "There is not an insect or small reptile that inhabits the soil beneath us, or the waters around us, that is not food for fishes in a greater or less degree. Worms of all kinds, flies, grubs, larvæ, cockchafers, crickets, leeches, snails, humble-bees, birds, mice, rats, all serve the turn of one fish or another, and so in turn help to produce food for man. Nothing living comes amiss, but doubtless some kinds of food agree with them far better than others. But we know very little on this branch of the subject. It is dreamland to us, with a very little waking reality." Some rivers produce larger trout than others, like them in all visible features. Mr. Francis compares the trout of the Chess, a branch of the Buckinghamshire Colne, with those of the Wick, little more than a good-sized brook, near High Wycombe. The may-fly abounds on the Chess, but is hardly seen on the Wick, and yet the Wycombe fish, attaining a size of from seven up to even ten pounds, and of a red colour deeper than salmon, is decidedly superior. Why? How is it that this little stream had not—for we fear sewage has even here done its deadly work—its equal in all England for the size and flavour of its trout? Mr. Francis surmises—and from our own experience of these waters we would think correctly so—that the fresh-water pulex or screw has not a little to do with the production of this marked superiority. "I have seen," says he, "the trout picking them at the walls which part the stream in some places, as rapidly as a child would pick blackberries from a hedge; and I am induced to think that this insect has much to do with the fineness of the fish; and the more so because when I have found it exist in any quantity, I have invariably observed that the trout are of fine size and in unusually good condition."

Happily there exist signs of an advancement of knowledge in the direction here under review. The intelligent angler now no longer takes for granted the clumsy and libellous imitations of insect life which are offered to him with commercial confidence by the tackle maker; but his observations as a naturalist being sufficiently advanced, he searches for and obtains the flies indigenous to the stream he is about to fish, and, as close as art can aid him, simulates the natural object. Mr. Francis Francis' "Book on Angling" points out how close is, or ought to be allied, the entomologist and the fisher; and that, although the angler may possibly be of service to the naturalist, a study of such works as the Rev. J. G. Wood's "Insects at Home," cannot fail of being highly advantageous to the angler. In a word, that all knowledge is so intimately blended that the acquirement of any one department must inevitably enhance the value of the others; and, as here shown, an acquaintance with the precise fattening food of fish and its use would materially tend to their sustenance and consequent increase.

In a future paper we hope to make some remarks and offer some instruction on the methods adopted for propagating and feeding such shell-fish as oysters, mussels, etc.; a kind of fish culture which is followed up with spirit in some parts of the Continent, and which might be carried out far more than it is in our own country as a profitable employment.

PRACTICAL APPLICATION OF THE FINE ARTS.—X.

THE ART OF MOSAIC (*continued*).

By P. H. Delamotte, Professor of Drawing, King's College, London.

We have already classified mosaic work according to the materials employed, and the manner of using those materials. We now intend to arrange mosaic work more according to the art shown than the style of workmanship displayed. We have also in a previous paper noted that the spread of Christianity had a vast influence on the character of the designs and the spirit in which they were carried out. This and many other political and social changes had their effect upon mosaic as well as upon other arts, and the various phases of the art thus produced have been divided into seven periods by Sir Digby Wyatt, whose exhaustive treatises we shall in the main follow.

The period to which he gives the name of *Classical* is traceable from the earliest times down to the general decadence of the empire. Two distinct schools of taste are traceable in this work; the one, belonging to what is usually called the Græco-Latin race, delights in figures of red or buff upon black grounds, or delicately coloured designs upon a flat tint of some depth of colour—naturally the designs of this school more or less resemble the style of decoration common amongst the severest artists of the two great peninsulas, viz., the Etrurians and the Dorians, and it also keeps up the connection which the latter show with Egypt; the other school is derivable from the East, and partakes of the magnificences of Babylonia, Assyria, Phœnicia, and Asia Minor. In all the work of this period we find large surfaces of even colour, and we notice that there is no attempt to conceal the ultimate fact of mosaic—viz., that it is made up of many small cubes. The joints are not hidden by coloured cement, nor are the tesseræ of any great size, but a uniform tone is produced at a moderate distance by the combination of these materials. This is true art, and should be aimed at in artistic workmanship. The materials should be used with judgment, certainly, but as the materials they are, neither concealing their natural imperfection, nor aiming at representing what they are not. It was just in the same way that we recommended the judicious use of the leading and the iron stanchions in glass painting, making the lines of the leading follow as much as possible the outlines of the design, but not scrupling for one moment to allow either lead or stanchion boldly to pass through the midst of flat colour if the necessity arose for it. So in mosaic designs the natural imperfection of the joint between the tesseræ should be recognised and used, and adapted to the circumstances of the case. A pleasing, even flat surface is produced by the regular disposition of evenly-sized cubes, whereas the contours of the figures, etc., are more thoroughly made natural to the eye by one or two lines of tesseræ following more or less the directions of the outlines. The study of ancient work of this period is of great importance to those who would carry this work to perfection, and fortunately for us the numerous remains in this country afford the means for this study. We have already given examples from the pavement at Cirencester; we here show two heads of great boldness of character. The very roughness of the outlines show how much power and grace can be obtained by unwieldy materials if treated in accordance with their nature. The British Museum and many local museums afford frequent examples from various parts of England, and these are deserving the attention of those interested in the cultivation of true art.

Fig. 27.

As we have here given two heads from the pavement at Cirencester, it may perhaps not be out of place here to mention the colours that we are unable to give in our woodcuts. In both heads the greater part of the flesh colour was produced by the cream colour of a fine hard freestone; this is heightened by a little yellow and some borderings of red, whilst the shadows are represented by the deep chocolate of red sandstone, and many of the outlines are of black terra-cotta. The hook of Ceres (Fig. 27) is of a dark bluish-grey, while the ears of corn adorning her head are produced by black and yellow; between these are interspersed dark olive-green leaves. The hair is black. In the head of Flora (Fig. 28) the flowers are of a bright ruby red, produced by tesseræ of glass coloured with copper. The leaves and stems are of the same dull olive-green as in the other head. One or two white flowers are introduced in the dark chocolate-coloured hair. The swallow on her shoulder is simply black and white, with one line of grey. Fig. 29 is a portion of the border round the head of Flora.

Another head, given in the last article (Fig. 18), is from the baths of Agrippa at Rome. Though of a coarser character of work, it still more clearly shows a complete mastery over the materials, and it is an especially good instance of the peculiarity we have noted above of the lines of the tesseræ following those of the design.

The second phase of mosaic work has been called *Latin*, and extends from the reign of Constantine at the beginning of the fourth century to the middle of the thirteenth. It is not confined to Italy, but is to be found wherever the Latin race spread their dominions, and is especially to be sought for amongst those nations that have retained an impress of the Latin language, institutions, and laws. It is distinguished by an absence of all Byzantine influence, but shows on the other hand strong traces of the race amongst which it was most in vogue. In this variety of mosaic we meet with very much work that reminds us of the classical period—even in many cases the ornamental borderings and divisions are the same. Fine specimens exist in the pavement of the cathedral of Novara, in the crypt and choir of the church of St. Bertin at St. Omer, and in the monumental slab of Frumualdus, Bishop of Arras, formerly in the cathedral church of St. Waast, now deposited in the museum in that city.

Concurrently with this last phase we have another which has

been named *Byzantine Mosaic*. This dates from the transfer of the empire to Constantinople in the fourth century, and does not appear to have flourished after the eighth. The first artists were transported from Rome by Constantine the Great, and their work naturally partakes of the character of that in their native country; but very soon an Eastern element developed itself, and this henceforth became the main characteristic. No doubt the finest specimens were originally to be found in Constantinople itself, but the remains at Ravenna, which in 404 A.D. became the capital of the Western Empire, and in 568 A.D. the capital of an exarchate under the Eastern emperors, now afford the finest examples we know; whilst San Marco, at Venice, carries on the taste once developed on the western coast of the Adriatic. In Ravenna the following churches all afford specimens of this class of work, and some of them are nearly covered with it—the two churches of San Apollinare, the one in the town, the other at a short distance from it, San Vitali, the tomb of Galla Placida, and the chapel attached to the archiepiscopal palace. Some of the work in Rome of this period shows a decided tendency to this school, though much of it is inferior to what had preceded it. The main characteristics are a gold background to be found everywhere, a calm dignity of expression, and a happy grouping of the figures.

Fig. 28.

As we mentioned above, some of these churches are almost covered internally with pictorial representations, and thus they come to form a part of the original design of the building, and the arrangement of the pictures is made subservient to the general features of the architecture. It is in this way that the art arrives at its perfection. It finds its fitting place as one of the handmaids of architecture, and in this position it fulfils its highest office. Next after a study of the old classical work, in order to see how the technical difficulties of the material are to be overcome, we should most strongly recommend a systematic course of observations of the Byzantine art, more especially of Ravenna and Venice, for the student who desires to see the class of subjects most adapted to delineation in mosaic, and the mode of treatment which is applicable to this art.

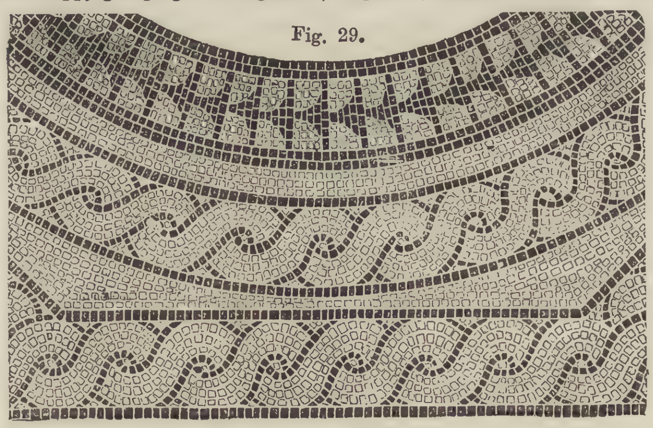


Fig. 29.

The *Græco-Italian* phase is the name given to the school developed by Greek artists on the congenial soil of Sicily, and carried on in that country during the time of the Norman kingdom. The cathedral of Monreale, begun 1174, is said to be the noblest and grandest instance of a church decorated entirely with mosaic, with the exception of St. Sophia at Constantinople, and San Marco at Venice.

The next class of mosaic work has been called the *Italian monumental*, and has for its principal seat Florence, the great artistic rival of Rome, though some splendid specimens are to be found in the latter city, especially in St. John Lateran and Sta. Maria Maggiore. We now come to the names of the artists who furnished designs for this work. The Florentines Andrea Tafi and Mino da Turrita learned the processes of the Greeks who worked in Venice, and Gaddo Gaddi afterwards carried on their work in that city; after which, in Rome, Pietro Cavallini and the Cosmati became celebrated. Thus the work was continued until the rise of fresco painting superseded its more costly but more permanent predecessor.

The production of work of the two remaining schools of mosaic, that Sir D. Wyatt calls the *Italian portable*, and the well-known *Florentine*, or *pietra dura*, has been carried down to the present day. By *portable* is intended that species which is really a continuation of the *opus vermiculatum minus*, and is principally employed to make copies of well-known masterpieces of great painters. The *pietra dura* is founded upon the *opus sectile* of the ancients, and is composed of the most durable materials matched according to their natural colours. Each piece is cut and ground into shape, and the thin slices are backed by pieces of slate or similar material.

In Rome and in Florence at the present day a large amount of work is done, and in Venice Signor Salviati has revived, to a great extent, the art well-nigh lost to his native town. In Rome the copying both of ancient mosaics, such as "Pliny's Doves" and of the masterpieces of pictorial art, form a continuous employment for the skilled workman collected in the Papal establishment. The original object of the Popes in establishing workshops for the cultivation of mosaic, was that such pictures as Raffaelle's "Transfiguration," the "Madonna della Seggiola," etc., might be transferred to a durable material that would not only defy the power of light and time to diminish their colour or brilliancy, but also place such precious relics beyond the risks to which canvas and colour are ever liable. But to train men to

the effective imitation of great works, it was necessary to practise them in smaller matters and on pictures of lesser note; hence arose a supply of works more within the compass of private individuals. It was no wonder that strangers in Rome, overwhelmed with the mighty works around, might wish to carry away some memorial of the precious relics of art which are the true objects to which devotion should be paid in the "slowly fading mistress of the world." A supply was afforded, and a demand arose for these works, and thus the Pope's workmen are trained for the work of supplying the great churches in Rome with imperishable copies of the greatest works of the greatest artists.

In Venice, as in Rome, a constant supply of work for mosaic-workers was afforded by the repairs required for San Marco; and Signor Salviati, a descendant of a house historically connected with art manufacture, having begun by restoring the manufacture of the glass for which Venice in the Middle Ages was celebrated, he continued his exertions in the cause of recreating lost arts, and having manufactured *smalti* such as was used by the ancient artists, he determined to cultivate the taste that had been displayed by them. Money being requisite, he obtained the necessary support from England, and in return he has sent to this country many excellent specimens of what he has been enabled to accomplish. The impetus given to architecture during the last twenty years has greatly influenced, as might have been expected, all the arts connected with architecture, and thus mosaic has again found the place which it once took among the kindred arts. In this matter Signor Salviati has done good service, since he not only has himself carried out much decoration with this material, so well adapted to permanent ornamentation, but he also prepares the material of which others can make use; and our own manufacturers of the terra-cotta tesseræ and the small tiles which can be introduced in various ways, avail themselves of his glass, and especially of the golden-covered glass so well adapted for backgrounds, and which the manufacturers in this country have as yet been unable to imitate.

SOLDIERING.—III.

BY A STAFF OFFICER.

EQUIPMENT OF AN ARMY—WEAPONS.

I HAVE said that we must constantly keep before us the fact that an army is an organism, the active energy of which depends on the nature of the spirit which pervades it. Nevertheless, as the object of the enrolment of an army is the development of physical power, it is all important for us to consider what material agencies can be employed to that end with the greatest effect. The two questions are so closely bound up together, that it is historically true that the changes in the nature of the agents employed have contributed more than any other cause gradually to change the nature of the discipline or prevailing spirit by which armies are held together. The armies of our day differ essentially from those which existed previous to the invention of gunpowder. The field of study with reference to recent times is in itself vast. Hence it is unadvisable for one who would learn the condition of modern wars in the most perfect degree, to occupy himself long with armies of the earlier period. Obviously the great change is due to a difference of *equipment*. Till fire-arms were introduced the great object aimed at in a soldier's equipment was that of rendering it impervious to arrows, javelins, and lances. All such considerations were swept away by a weapon which drove its bolts through any weight of metal that men could carry, scarcely less easily than through broadcloth. Defensive armour almost entirely disappeared, and the conditions under which soldiers have now-a-days to be equipped present an altogether different aspect. I include under the general term equipment all that must be actually present with the fighting portion of the army at any one moment. We shall have to consider at a later stage how the army has to be provided with further supplies of its chief requisites.

The different portions of equipment may be conveniently classed under the following heads:—First, those which are re-required for actual fighting purposes; secondly, clothing; and, lastly, such necessaries as it is indispensable that the fighting part of the army should have actually at hand.

First, as to the weapons we now employ. I need not dwell on the details of the subject, for a full description of all of them has been given in papers of THE TECHNICAL EDUCATOR specially devoted to that purpose. But they concern us here in so far as their special characteristics affect the question of organisation.

We have, then, two great classes of fire-arms. First, as being in fact the more important, the small-arm; and secondly, the big guns: the one such as a man can carry; the other comprising all guns beyond that size up to the most enormous piece of ordnance which can be invented. The progress of improvement in fire-arms has gradually reduced to an altogether secondary importance all other kinds of weapons. I say it has "gradually" brought this about, because we do still employ hand-to-hand weapons in fighting. The bayonet, the sword, the lance are still in use; but, as time has gone on, the employment of all these weapons has receded in importance, and battles are more and more fought out with fire-arms, all other weapons being only accessory.

One other agent, however, the value and force of which has been appreciated from the earliest times, remains almost as important as ever, if its action on the whole be taken into account, though that is scarcely true of its present effect in mere fighting. The horse has been always employed by man for innumerable purposes in war, but in his special use for actual fighting purposes his action is so important, that in order to take full advantage of it we continue in this one instance to employ hand-to-hand weapons as those of primary importance, fire-arms only for secondary objects. In the charge, in fact, the horse and man become themselves the projectile, of which the weapon held by the man is only the point or edge.

The subdivision of armies into the three so-called "arms" of the service—the "infantry," the "cavalry," and the "artillery"—is due to the necessity of employing effectively these several agents in war. The training which, as experience has taught us, is required for the soldiers who are to fight on foot, and who can be employed in using either fire-arms or hand-to-hand weapons, is necessarily very different from that either of the cavalry—the horse-soldiers; or of the artillery—those who are employed in managing the big guns. Simple as these facts are, I can hardly insist too strongly on this, that the whole use or abuse of each of the three arms turns on the original cause of the subdivision of armies into them. The question always is, how best to bring out the full effectiveness of the *weapons* of the infantry and of the artillery, and the horses of the cavalry.

There are two somewhat curious facts which, so far as I am aware, have not been pointed out before. Hardly any recent period of war, however long, appears to have developed during its course a great improvement in armament which has been so perfected as to be successful during that war. Scarcely any one of the great European wars of this century has commenced without some improvement upon the material of war which has been effected during the preceding interval of peace. Thus, percussion caps were introduced shortly before the Italian war of 1848. Rifled small-arms had come into effective use just before the Crimean war. Rifled ordnance was used freely by the French in the campaign in Italy in 1859. The campaign in which Austria and Prussia crushed Denmark cannot fairly be reckoned among these. It was in fact the trial ground for the breech-loader, which came into effective use on the Prussian side in 1866. Lastly, in 1870 we have the mitrailleuse.

In all these campaigns except the last the superior armament was on the side of the victors. It must be carefully borne in mind in reading of any campaign, that these questions of armament are always of extreme importance. They are constantly ignored even by regular military historians, except where a traditional interest has in some way attached itself to a special case. I may cite, as a notable instance of this, that though, as I have said above, percussion caps had been invented some time before the war of 1848, I have been entirely unable to find any record as to whether they were used on either side, or on neither, during the campaign. Yet military criticism, without a knowledge of such points as these, is entirely unsatisfactory. True deductions may, no doubt, often be drawn from the bare outline of events; but the general who feels that he possesses a practical certainty of success in small details, finds this fact tell in his favour to an extent which enables him to venture many things which it would be very rash to attempt under less

favourable conditions. The fact that the particular improvement of any given period has ceased to be the one that we now adopt, by no means proves that it was not of almost decisive importance at the time when it was introduced. Thus Frederick the Great of Prussia was much assisted in his victories by a substitution made in his day of iron for wooden ramrods. The wooden ramrods broke, and were at best so much more clumsy in loading that his men were able to fire much more rapidly than their enemies. Such inventions as these always in two ways increase the power of an army. It is not merely that they have a greater physical effect. They give a confidence to one side, and discourage the other so much, that after a victory or two won by their aid, men come to believe on both sides that those who possess the superior weapon cannot be beaten. Then they certainly are not likely to be so.

To attempt, therefore, to study the motives of a general's action, and either to judge his conduct or to learn from it without ascertaining all that can be found out under this head, is certainly misleading; the more so because we are all apt to fancy that success is in each particular instance a sure proof that skill has been displayed by the successful; a conclusion scarcely more sound than the deduction that a man is a good whist-player because he has won a rubber, or a bad one because he has lost it. To carry the illustration further, a good whist-player may sometimes calculate too much on the chances of a very strong hand. He is mistaken, but his play may have been correct. So the assumption that a general, with certain special advantages in his favour, such as those I have described, has been wrong because he has attempted what under other circumstances would have been rash, and has failed, is certainly not a fair one. What, moreover, is more important is, that the deductions so drawn are apt not to be just, and to lead men to neglect the qualifications which are always necessary in the application of general principles.

It is in the infantry that the successive changes of armament have produced on the whole the most important revolution. It will be necessary to observe how these have gradually affected the drill when we consider that subject; at present we must note the manner in which these changes have tended to modify the qualities which are of the greatest practical value in a soldier. As long as it was possible to fight out battles hand to hand, a certain fiery dash and eagerness to close was all important. But as the deadliness of fire was more and more appreciated, and generals began to perceive that it was possible to rely upon it more and more, provided it were brought to bear with proper effect, a change came over this part of the question also. It was found even in the Peninsula that what told with the greatest effect was a calm readiness to wait in obedience to orders till the moment had arrived when the powers of the weapon could be brought to bear with the deadliest result. One of the ablest of the generals opposed to us in Spain (Marshal Bugeaud) has given a most lively and generous description of the manner in which a fight in those days between his own troops and ours used to take place. The following may serve as an epitome of his account, the French being, he says, almost always the assailants:—The attacking columns move to assault the position held by the English just beyond the crest of some gently rising hill. The English, either at first lying down or standing with the butt-ends of their rifles on the ground, give no sign of their existence, except a line of motionless red, which just shows and no more along the crest, while behind it here and there an officer is seen riding quietly up and down. At first the French dash forward with furious courage, chattering a good deal, abusing the English most savagely. The excitement increases from moment to moment. One after another cannot be restrained from breaking the ranks, that he may relieve his feelings by a shot at the enemy. The column becomes more and more confused. As they get further and further up the hill the excitement and hurry tell more and more: the pace cannot be kept up. They realise ever more and more unpleasantly the fact that all their excitement and flurry have produced no effect upon the red line above them. These feelings have full time to react upon the previous over-excitement. At last an unpleasant chill succeeds, and now they are within point-blank range of the enemy. They hear a single cool word of command repeated all along the English line. Down come all the muskets towards them. A moment more. Then comes a volley of which few shots go astray. The smoke clears away. Moving straight down towards them they see a line of bayonets. Then a loud cheer rings out from the hitherto silent ranks. These are coming on now steadily, rapidly—with an evident intention not to stop—straight at them. The strain is too severe. The column does not wait to be attacked, but breaks and flies. "Never," says the old marshal, "did I see other than one end to it."

The description tells more than a hundred dissertations on the theory of the thing in what way in those days the weapons could be made to produce the greatest effect. The fire of modern small-arms has become so infinitely more deadly, its range and its rapidity of fire are so very much greater, that many new considerations have to be taken into account. But of one fact we may be perfectly sure, that no application of modern weapons can be effective which is not based upon the same thorough appreciation of the fact that men are not machines, that the effect you produce is not in mere proportion to the number you knock over, as if they were pawns or ninepins; but upon the extent to which you also work upon their imagination and spirit. It would be difficult from the recent campaigns to obtain an illustration as telling; a fact for which it would be easy to account without assuming that anything has occurred to modify the importance of such considerations. General Grant, however, now President of the United States, used to say, "When you see that your men are pretty nearly exhausted and are beginning to waver, then is the moment to close; for depend upon it your enemy is nearly in the same condition." I insist upon this for these reasons. Beyond all question the fire of modern weapons has become so deadly that our attention has now to be directed, and perhaps it is not unfair to say directed mainly, to the object of diminishing the effect of the enemy's fire, at the same time that we endeavour to make our own as effective as possible. But for all that, there is no sign whatever that the following statements are less true than they were formerly: that the critical moments of battles arrive when men's minds have reached a certain point of tension; that the weapons will be used with the greatest effect by him who succeeds in making them tell most heavily, both in producing that state of tension in the enemy, and in over-straining it; and that tactical skill will now, as formerly, consist very largely in appreciating correctly when the moment has arrived when decisive action will break down the nerve—the resisting energy—of the opposing forces, and in constantly feeling, as it were, the moral pulse of the forces to be led to victory. Of course, I am not here speaking of the combinations by which preparation is made for success. Those are strictly "tactical" questions with which these papers are not concerned. I speak here only of the direct application of the weapon, as a necessary introduction to certain matters of training which depend on it, and for the moment only of the infantry weapon.

Now it will be observed that in the description given by Marshal Bugeaud, the difference in effect of the irregular isolated shots sent by occasional Frenchmen against the English line, and the single volley all poured in at one time, is very striking. It is impossible to doubt the difference in effect produced by a great loss suddenly inflicted, from that caused by the same loss due to a long continuance of apparently not very effective fire. In the one case the assailants see and feel all round them the loss their numbers have sustained. Their adversaries seem to them not to have attempted to oppose till the opposition began to be most effectual. Hence, the assailants have no previous consciousness of success to carry them on. The defendants have no consciousness that their assailants have been gaining on them, but only that they have been allowed to pass over without opposition space where the fire would not have been effective. On the other hand, if the defending force had fired irregularly at the assailants, that irregular fire at considerable distances would not have produced any decisive loss. The assailants would have gained confidence by their successful advance despite of it. The obvious inefficacy of their own fire to stop the attack would have proportionally cowed the defendants.

Such are the arguments by which the superior efficacy of volley-firing and "reserved" fire have been upheld. To these it must be added, moreover, that the number of men you can trust to fire calmly and leisurely, taking proper aim, is not so great even in the best trained army as might be

supposed; that in a volley this can be attended to sufficiently by the officers simply looking along the line. Nevertheless, we are assured by the best authorities that in practice, as soon as a battle has begun, separate firing is the rule and not the exception. It is not a little notable that the nation which is supposed, and rightly supposed, to have developed more than any other the individuality of the soldier, has especially endeavoured in its preparation for war to retain the advantages of the system of volley-firing, and to combine them with those of the free action of the individual. Even in that special form of fighting, the development of which has been due to the nature of the new weapon—skirmishing—the Prussians in their training exercises always move up small bodies of men in support of any particular part of the scattered skirmishers who may require assistance, and make them fire volleys till the opposition is overcome.

Nor is this advantage of the sudden telling effect of a greater mass of fire poured in at one time the only one which is obtained by having the men kept together as long as possible, and brought together again as soon as may be. For under the awful excitement in which men find themselves in the stress of battle, it often seems to turn on a hair whether the very violence of the feeling will lead them to go on in confident and victorious advance, or to fly in ruinous disorder. Then nothing so restores their spirit and gives them energy for fresh struggles as to find themselves among their companions, standing in the place they are accustomed to. Losses then seem less terrible than when each man by himself can let his own imagination run wild, and when the fearful sounds on all sides leave an impression far above the reality of danger. It is necessary to state all these modifying circumstances first, in order that their effect may not be ignored; but the fact which remains of the most importance in the latest phase of war is, that in order to get the full value out of the weapon, it is absolutely indispensable to increase the latitude which is allowed to the individual soldier in his use of it. At the same time the space which must be covered by a given number of troops must be very much greater than it was formerly, in order that the enemy's fire may not cause the awful destruction which would be produced in densely crowded ranks. The possibility of a charge with the bayonet under almost any conditions is now a matter of grave dispute, and, as a result from all the conditions above enumerated, it may be pretty safely asserted that the general manner in which the infantry weapon will be employed in future will be somewhat of this kind. In attack, when moving over open ground, men will advance as rapidly as possible, and in as scattered an order as may be. Where isolated cover presents itself sufficient for individual men, there it will be taken advantage of, in order to enable the advancing assailants to bring fire upon the defendants. Here the rapid manner in which the new weapon can be loaded will tell so far as the point goes in favour of the attack; for formerly it was scarcely possible to employ the small-arm with effect in advances at all. The delay occasioned by desultory firing was too great in proportion to the advantage gained by it. Now, thanks partly to the rapidity of fire, partly to the new method of advance in deep "clouds of skirmishers," some will be always firing whilst others are advancing. But always when possible knots will be formed under the orders of officers or non-commissioned officers as often as cover can be obtained for them. These will then, if possible, from their new position bring an effective volley-fire to bear on the defendants, and as soon as opportunity offers they will again scatter in order to advance. Finally, the attack will be decided by a gradual accumulation of troops so near to the point to be attacked that the fire of the defendants is completely overpowered, and entry forced into the position with comparatively little opposition. Always, however, the great danger will be lest too great a mass should accumulate at any one spot. The advantage of numbers must be sought rather in obtaining a vast number of points from which fire can be brought to bear, and in extending over a great expanse of ground, in order to try every part of the line of defence, and find its weak point, than in mere accumulation of weight, and an imposing body for the final rush.

On the other hand, it is idle to deny the direct advantages which man for man, and at the point where the attack occurs the defence has gained by the development of the effectiveness of fire. Since during the time that a man is moving forward he cannot be shooting, it follows at once that the man who is shooting from a fixed position gains in proportion to the effectiveness of the fire which can be delivered during the time taken by his assailants to move over the ground. So great is the advantage which, from this cause, the new weapon confers on the defendant, that were it not for two considerations it might almost be considered decisive. The first is, that in the best situation which can be selected for taking up a defensive position there is always some point which is weaker than the rest, more exposed, that is, to the assailants' fire, and the access to which is less under the fire of the defendant; and that while the defendant necessarily has to be prepared for attack at every point, the assailant is able to gather his forces against the point which he selects as the most vulnerable. The other is the enormous power of modern artillery, which enables an assailant to bring against the position he assails an overpowering fire long before his infantry are ready to move to the assault. This leads us naturally to the next consideration in regard to armament—that which relates to the big guns. There are some further points in the question of attack and defence which are connected with the effective employment of the infantry arms, but they are much more easily understood when we consider them with reference to the "drill" which has been devised in order to enable armies to take advantage of the power of their weapons, that I shall leave them until this part of the subject is brought under consideration.

TECHNICAL DRAWING.—LXIV.

DRAWING FOR BRICKLAYERS.

FIG. 525.—The design of the floor given in this example is of a very simple character, and consists of octagonal and square floor-tiles. Tiles of this character, and of varied manufacture, are now made by several firms in this country, and may be had to suit any building, or adapted to any sized floor. Numerous beautiful specimens of these may be seen in the South Kensington Museum. To draw this pattern, divide the whole width into three equal parts, and draw lines dividing the surface into three equal strips, or as many as may be required in the design. Next draw lines at right angles to these, thus dividing the whole surface into squares.

In one of these, as A B, draw diagonals, and from the angles, with a radius extending from the angle to the centre (C), describe arcs cutting the sides of the square in D, E, F, G, H, I, J, K. Join E H, I K, J G, and F D, and an octagon will be inscribed in the square, as shown in Fig. 525, or on a larger scale in Fig. 526. Now measure the distance from the angle of the square to I or K, and set off the length on each of the four lines meeting at the angles of all the squares. Join these points; the design will then be completed, and may be coloured according to taste. The squares may be formed of four triangular pieces, or may consist of complete squares.

In the following study (Fig. 527) another design for a tiled floor is given, the forms of the tiles being hexagonal and lozenge. In order to guide the student in drawing this pattern, the annexed elementary figure (Fig. 528) is given, from which the precise construction will be seen.

Draw the regular hexagon A B C D E F. Divide each of the sides into three equal parts, as G, H; I, J, etc.

From the various points draw lines across the hexagon, parallel to the respective sides. These intersecting, as at K, L, M, will give a smaller hexagon in each angle of the original figure, leaving the star in the middle, and a triangle, as G H M and I K J, in each of the sides. These triangles are the halves of the lozenges of six surrounding stars.

Fig. 527.—In commencing this pattern, draw the hexagon A B C D E F, and adjoining it construct the others, which are to contain the smaller hexagons. Finish each in the manner shown on the previous figure, and colour according to taste.

FREEHAND DRAWING.

It has in all the previous lessons been urged on artisans, to whatever branch of industry they may belong, that *all* drawing cannot be executed by the aid of instruments, and that it is therefore indispensable that they should acquire some power in drawing by freehand, guided only by the eye. The question

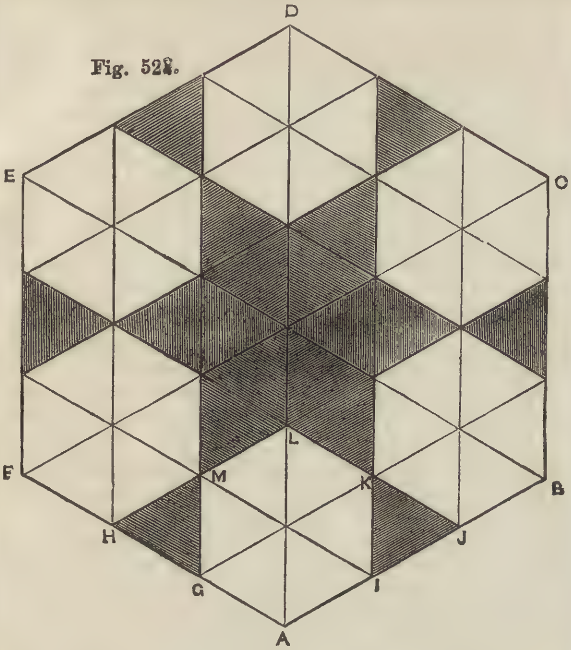


Fig. 528.

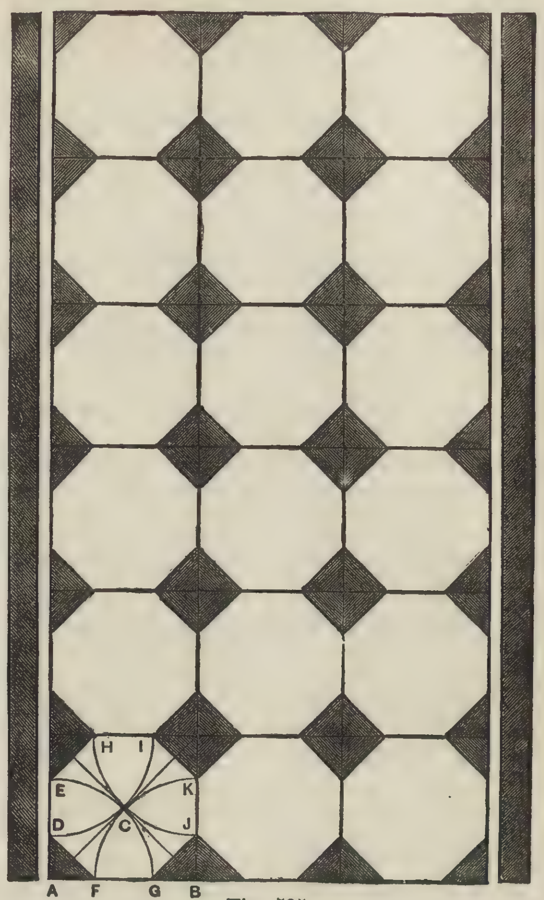


Fig. 525.

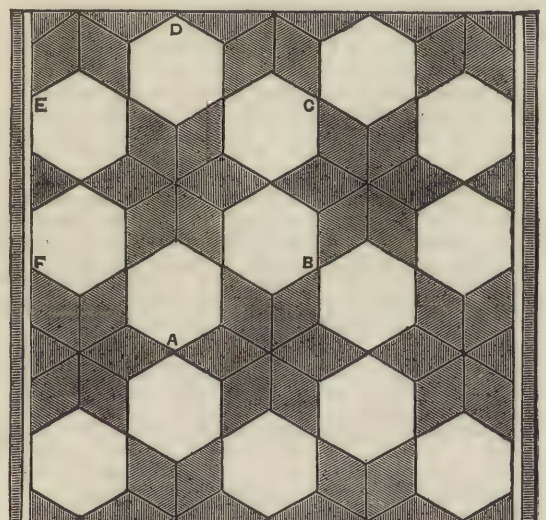


Fig. 527.

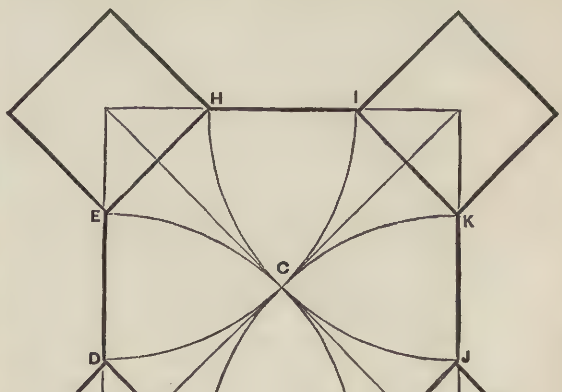


Fig. 526.

should not be asked, "Does a bricklayer ever require freehand drawing?" for although education should as far as possible be thoroughly practical in its character, still it is unwise for the young to study in such a narrow track. A bricklayer may not absolutely require freehand drawing in his work; but, for all that, the contemplation of graceful and beautiful forms refines and elevates his taste; and the accuracy of perception obtained by the practice of drawing rigid forms is such that it frequently enables him to check the work done by means of instruments, and to detect where an error has been made. Besides this, a bricklayer need not always draw bricks only; he will in time draw buildings, with their decorations; he will, by the aid of a knowledge of object drawing, be able to make sketches of any building or place he may visit; so that, from every point of view, the student is urged to follow the elementary course here laid down as a stepping-stone to higher subjects.

In order to avoid repetition in these lessons, and to economise space, the subjects of the freehand exercises in "Drawing for Stonemasons" may be used at this stage; they will be found at page 265, Vol. II., of THE TECHNICAL EDUCATOR.

Assuming then that these have been satisfactorily accomplished, we proceed with

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

FOUNDATION OF BUILDINGS IN GOOD SOIL.

The meaning of the term and the general principles of foundations have been treated of in lessons on "Building Construction." The subject is here continued in order to give the student a further insight into it.

The ground on which a building is to be erected should be carefully examined to a considerable depth, and if it proves to be good throughout, such as rock, gravel, or soil of a sound, uniform quality, not liable to be altered from time to time, either entirely or in part, by the effects of water acting below the surface, a trench is cut all round, and carefully levelled; in this the walls are commenced, giving, however, to each wall a base somewhat thicker than that part of it which is to appear above ground.

If the ground to be built on should happen to be very irregular, such as the side of a hill, which often occurs in practice, instead of cutting the whole trench intended for the building to one general horizontal level, it is usually cut to several levels in steps or terraces, or, as it is technically termed, "benched out." When a building is to be erected, the ground should not on any account be cut to an inclined plane, although this method is sometimes used in low boundary walls, as in the north enclosure of the infantry barracks at Chatham, where the courses of bricks are all laid sloping. In any other description of wall this arrangement would be perfectly inadmissible.

PHOTOGRAPHY.—VIII.

By J. C. LEAKE.

DRY PLATE PROCESSES.

ALTHOUGH for excellence and certainty of result the wet collodion process already described is unrivalled, yet the difficulty and inconvenience of at all times carrying the necessary chemicals and a portable dark room to the scene to be photographed; are such that a process by which plates capable of receiving an impression, and which can be prepared and developed at home, has always been a desideratum to the out-door worker. Much attention has been given to the production of sensitive dry plates, and at length several processes have been invented, which are as nearly as may be expected equal to that upon wet collodion, although the same amount of sensitiveness or certainty cannot be at all times secured. Enough, however, has been done to render these processes exceedingly useful where the subject will allow of a moderately long exposure; and in some cases, such as dimly lighted interiors, where the exposure would be too long for the proper keeping of wet plates, those prepared as we are about to describe will enable the operator to obtain pictures which it would be impossible to produce by any other method.

There are, as we have before remarked, various processes by which sensitive dry plates may be prepared, but their number may be reduced to two or three for practical purposes, the others being for the most part merely modifications. Of these standard processes, that known as the collodio-albumen stands first, both as regards delicacy and certainty, as well as for its extraordinary keeping properties. As may be implied from its title, this is a combination of the albumen and collodion processes, both of these substances playing an important part in the production of the picture. For the production of sensitive plates by this process two nitrate-of-silver baths will be required; and we may here remark that as a rule the silver baths required for exciting the collodion film in dry-plate work should never be of less strength than forty grains to the ounce of water, and should be kept slightly acidulated with acetic acid.

It is also advisable to keep separate bath solutions for wet and dry plate work, as the conditions required are mostly different; attention to this point will save much trouble and vexation. For exciting the collodion film a bath should be mixed containing forty grains of nitrate of silver to the ounce of distilled water. To each pint of this solution add two or three grains of iodide of potassium and enough acetic acid to freely redden litmus paper. The second nitrate bath which will be required for exciting the albumen must be prepared as follows: nitrate of silver, thirty grains; distilled water, one ounce; dissolve and add one ounce of glacial acetic acid to each pint of solution. These baths must be kept each for its own purpose, or failure will result. Next prepare the following solution: distilled water, one and a half ounce; pure albumen (from fresh eggs), five ounces; iodide of potassium, twenty grains; bromide of ammonium, five grains. Dissolve the salts in the water, and add to the albumen in a large bottle, as before described for the preparation of albumenised paper; and after a few minutes' shaking add from forty to fifty drops of strong liquor-ammoniæ; again agitate until the whole becomes converted into froth, after which it should be allowed some hours to settle. It must always be carefully filtered before use. With these solutions prepared we may pass on to the manipulative details.

Any good bromo-iodised collodion will answer, but a sample should be selected which adheres well to the glass, and it should be remembered that a highly-bromised collodion will be most successful in all dry processes. After coating allow the film to become well set before immersion in the nitrate solution, and allow at least four or five minutes for the conversion of the iodide contained in the film. When removed from the nitrate bath, wash the film well first with distilled and afterwards with common water, in order to remove the whole of the free nitrate of silver. Pour into a flat dish, which must be scrupulously clean, enough of the following solution to amply cover the plate: iodide of potassium, three grains; water, one ounce; and allow the plate to remain in this four or five minutes, or while a second plate is in course of preparation. Wash well with clean water, drain, and pour over a portion of the iodised albumen, allowing it to soak well into the film. Allow the first quantity of albumen to flow off the plate into the sink, and repeat the operation with a fresh supply of solution, reserving the surplus for the first coating of the next plate. Set the coated plate to drain upon blotting-paper. It is a good plan to provide a clean box or cupboard in which the plates may be set to dry, as the albumen is exceedingly liable to attract particles of dust, which would produce spots in the finished picture. When the plate is dry (and it may be dried by artificial means if required, being in its present condition nearly, if not quite, insensitive to light), it will be ready for immersion in the second nitrate-of-silver bath. Before this immersion, however, it is better to thoroughly dry the film before a fire, making the plate quite hot, or blisters will probably ensue, and the film may be broken. After immersion in the second bath for one or two minutes the plate should be removed, again thoroughly washed in clean water and dried, when it will be ready for exposure in the camera. Respecting the exposure little advice can be given, except that as a rule plates prepared as above described will require at least four times that necessary for wet collodion, and frequently even more. One of the great faults of inexperienced dry-plate workers is that they frequently under-expose their pictures. Over-exposure can mostly be remedied in the development, but nothing can possibly be done with a plate if the detail in the darker portions be not properly impressed.

The usual developer for plates prepared as above described is composed of a saturated solution of gallic acid, made by pouring boiling water upon the crystal and agitating, pouring off the solution when cold. A quantity of this solution should be

prepared and filtered, and a small proportion of a ten-grain solution of nitrate of silver added before pouring over the plate, which should previously be wetted, in order to facilitate the flowing over the surface.

In the case of small plates, a sufficient quantity of the developing solution may be poured into a dish and the plate immersed, but care will be required in order to avoid stains, if the solution be not kept in motion, and as soon as any discolouration of the solution is observed the plate should be well washed and a fresh quantity applied. To those accustomed to the rapid development of collodion negatives the process in the case of dry plates may seem long and tedious, a collodio-albumen plate seldom developing in the way we have just described under half an hour. Care must be taken, however, not to make the negative too intense, as the deposit in this case is of a peculiar yellow non-actinic colour, so that a negative which appears to the eye thin and translucent is chemically sufficiently dense to yield a vigorous proof, while if the density were carried to anything like that usually necessary in a wet collodion negative the print would be hard and utterly useless. In case of under-exposure, or if the development should be unusually tardy, it may be hastened or completed by the use of a solution of pyrogallic acid, as follows: pyrogallic acid, two grains; water, one ounce; glacial acetic acid, twenty minims. This solution must be poured on and off the plate, and not used in a dish, as its action is extremely rapid, and must be carefully watched. Of course the usual addition of a few drops of nitrate-of-silver solution must be made before applying it to the plate. Sometimes the development is effected by means of pyrogallic acid solution entirely, and this is the modern practice, but it is not so safe in the hands of the tyro as the slower method by means of gallic acid; and we would therefore suggest that its use be deferred until the operator has gained some experience in the development of dry plates. When the operation of development is completed the plate may be washed, and fixed in a saturated solution of hyposulphite of soda as usual. The process we have now described is one which may be easily and safely worked, and although there are others which are more rapid and perhaps more simple, it is the one which the beginner should always commence with, as being likely to produce less failure and disappointment than those of a more delicate character, such as we shall describe in our next paper.

SANITARY ENGINEERING.—XVIII.

CISTERNS AND ECONOMY OF WATER—VENTILATION OF PIPES.

In two preceding papers (XVI. and XVII.) we briefly dealt with the methods of water-supply for villages and towns; and we now proceed to give the detail of various inventions for storing and also for economising the supply thus obtained. In the last century cisterns were almost invariably made of lead, in some cases cast solid of sufficient thickness to be fixed without external casing; the outside was often decorated with panelling in designs, and sometimes with coats of arms. The usual mode, however, was to provide a strong wooden cistern, which was subsequently lined with lead soldered together at the angles, either cast in sheets or rolled in a mill, described in the first case as "cast," and in the latter as "milled" lead; and this latter system is still extensively in use.

Within the present century, however, several other materials have been adopted for the purpose—*e.g.*, cast iron in one piece for small cisterns, and in a number of plates jointed together with flanges and bolts for those of larger dimensions, the joints being rendered water-tight with cement. Examples of this class of construction may be seen in the water-tanks for the supply of the engines at most railway stations.

The introduction of slate is, however, the most important feature of modern times in the construction of what may be termed household cisterns, and as it is much cheaper than lead, it has almost entirely superseded its use for all common purposes. The increased facility in obtaining what is called slab slate of late years, renders it possible for all, except very large cisterns, to be constructed with the ends, sides, and bottom each consisting of one single piece of slate. These are rabbeted together at the angles, confined in their place if necessary by small iron bolts, and the joints rendered water-tight with red lead. As slate, from the density of its texture, is scarcely affected by atmospheric changes, when the work is once properly executed, these cisterns are perfectly efficient. They are also free from an objection that applies to lead of all descriptions, and that is, that especially with soft water, when the water remains for any considerable time in contact with the lead, a chemical action takes place by which the water holds a certain quantity of lead in solution; and if this be allowed to proceed to any extent, the result when the water is used for drinking is very deleterious, producing the symptoms which are well recognised as those of lead poisoning.

Another material recently introduced for this purpose is sheet iron, which should always be galvanised to protect it from rust. The sheets are riveted together, and, where the size is so large as to require it, strengthened with iron cross-braces. This material is largely used for ships' tanks, as well as for household cisterns, and most of the large workhouse infirmaries erected recently, and also the large groups of buildings carried out within the last two or three years for the Metropolitan Asylums' Board, have been provided with cisterns of this construction.

Where, however, as is often the case in country houses, the general storage for the water is below the level of the ground, a brick tank is the usual receptacle. This can be made perfectly water-tight by a lining of cement within, and when the size is unusually large and the depth considerable, an outside coating of asphalte may be employed with advantage.

Having thus described the materials for the construction of cisterns in ordinary use, we now give the detail of various contrivances for economising the water-supply.

In districts where the supply is limited, or in houses where the cistern accommodation is comparatively small, it becomes important that the requisite flushing should be done with the minimum quantity of water, and for this purpose various inventions have been introduced. The one shown in Fig. 10 is Hooker's pattern, divided into a smaller and larger compartment, with levers and valves so arranged that the contents of the smaller cistern only are discharged for flushing purposes; the same action that releases the water closing for the time the connection between the two, which is restored when the operation is complete; the main store being thus retained intact, and the smaller portion refilling itself immediately.

Our second illustration (Fig. 11) shows a flushing cistern of somewhat similar construction, but so arranged as to be independent in itself, and to be attached to any ordinary larger cistern already fixed or otherwise, the same object being attained.

Our third sketch (Fig. 12) shows another adaptation of the same principle, but with a horizontal instead of a vertical division, the whole construction in this case being of cast iron.

In a previous paper we have had occasion to call attention to the difference between "constant" and "intermittent" supply, and our next illustration (Fig. 13) shows a contrivance for the economical supply of water to a closet where there is a *constant* supply at a considerable pressure, for which purpose only it is adapted. The air-chamber, which is of cast iron, must be connected with the main, and perfectly air-tight. The weight of the head of water compresses the air within the chamber, and fills it with water up to a certain point, the quantity being sufficient for the thorough service of the closet. When the closet is used the connection with the air-chamber is opened, the compressed air regains its original volume, discharging the water forced in by the pressure, the same action severing the connection with the main, which by the return action is again opened, when the air-chamber again charges itself as before, about two minutes being the time required, or even less.

This apparatus, which is called Common's patent high-pressure closet, has been used extensively and successfully in Brighton and other large towns where the constant supply is in operation. In a subsequent paper of this series we propose going in fuller detail into the various descriptions of closet apparatus, and therefore omit at this point any description of the remaining portion of the sketch, which is only introduced as an illustration of a certain class of methods for economising water-supply.

Regulators, of which Howard's patent is perhaps the best of its class, are another means of attaining the same object. They are attached to the water-service at its junction with the apparatus, and not to the cistern, and consist of a brass valve so arranged that the delivery of the water can be regulated by

a screw at pleasure, in accordance with the head or body of water to be dealt with. The rush consequent upon the working of the ordinary closet is thus avoided, sufficient water only being delivered to do the work thoroughly without waste. When the water, however, is charged with any foreign matter, the small aperture in the valve is apt to clog, and thus its efficiency is interfered with. In these cases Underhay's system may be adopted with advantage. Here the supply of water is received into a valve constructed with leather, like a bellows, the same result as before—a gradual discharge—being obtained; the leather, however, is perishable, especially if it be exposed to damp externally.

Having thus briefly described some of the methods in ordinary use for economy in the use of water-supply in connection with drainage, before going further into the detail of valves and closets, which will form the subject of our next paper, we wish to call especial attention to a matter we venture to think not generally understood, and that is the ventilation of pipes. meter, and then the pipe itself becomes as it were the flue by which the remainder of the system with which it is connected is ventilated; and in some cases this is so completely carried out, where unusual care is required, that the space between the bottom of the valve and the water in an ordinary valve-closet has a small air-pipe running into the ventilating soil-pipes. We may mention Sandringham House as an instance of the adoption of this precaution. The next point is to prevent any foul air from becoming what is technically called *water-bound*, *i.e.*, that when flushing takes place, a free escape should be provided for the air displaced, which, unless this is done, bubbles up through the water by which it is supposed to be hermetically confined, with the usual unpleasant results; and sometimes even when the plumbers' work is perfect in itself, a want of attention to this same point of water-bound air in the drains will produce the same result. Objections are frequently made to erecting closets in confined situations from fear of the want of general ventilation; but if the above cautions are carefully attended to

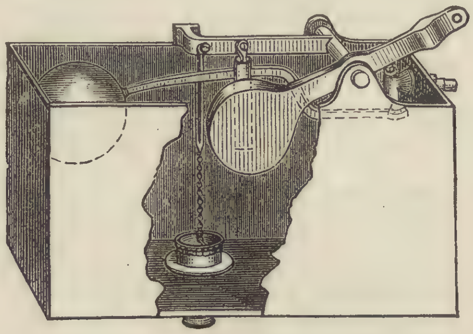


Fig. 11.

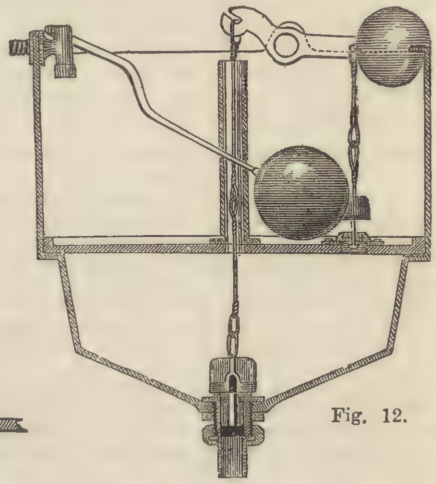


Fig. 12.

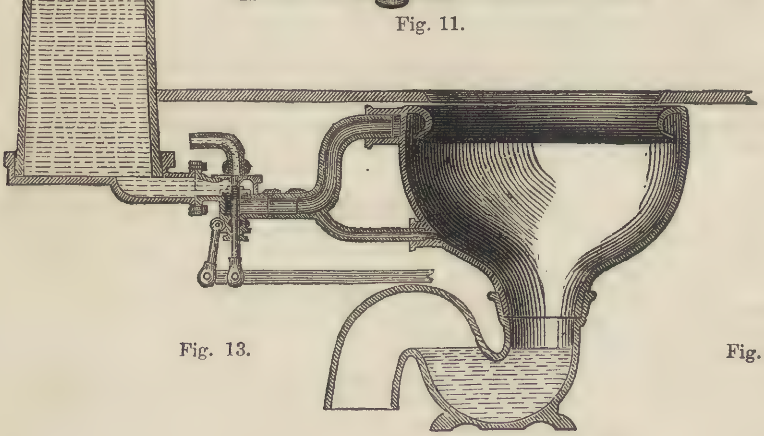


Fig. 13.

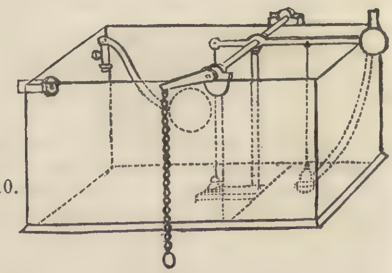


Fig. 10.

Lead is still the material generally in use, and will probably continue so to be; but whether of lead or of iron, or of any other material, our remarks will equally apply. One of the most important sanitary requisites in buildings of any kind is good plumbers' work; and there are two all-important requirements. The first is, that the strength of the material shall be sufficient, and the work well executed, as in no trade is perfection of workmanship more absolutely necessary, the least defect revealing its presence by its unpleasant and unhealthy consequences. But the second is equally important, and that is ventilation, as we shall proceed to explain, for the work may be perfectly well executed, and yet if this second requirement be either neglected or misunderstood, unsatisfactory results ensue, the cause of which is often obscure and difficult to trace. The great secret is to provide for the escape of all foul vapours to the outside air by means of the pipes themselves. Ordinary building specifications, as drawn even by the best professional men, are often wanting in explicit detail in this respect. The common wording is, "provide all necessary air-pipes," the details being too often left to the discretion of the working man. Every soil-pipe should have a ventilating-pipe from its topmost point, communicating with the external air, of not less than two inches in dia- by an expert, they ought to be absolutely and perfectly free from smell in whatever position they are placed.

This question of ventilation is all important in matters connected with drainage. Miss Nightingale says, "I have met just as strong a stream of sewer air coming up the staircase of a London house as I ever met with at Scutari, and this sewer air is retained in the bedrooms. No house with an imperfectly trapped pipe communicating with the sewer from the sink, can ever be healthy, and may at any time spread a fever among the inmates of a palace." The recent (1871-2) illness of the Prince of Wales has given only too striking confirmation to this well-founded observation. In our present paper we have given, as far as our limits have allowed, some guidance as to the general principles to be adopted for the complete avoidance of all danger as far as internal construction is concerned; and as we proceed with the subject, we hope in some subsequent paper to show how by the proper trapping of drains external to the house, with ventilation always kept in view, the evils which we fear are only too common may be effectually guarded against, and the noxious gases evolved from sewerage harmlessly discharged into the external air, and typhoid fever, with its cognate disorders, effectually kept at bay.

MINING AND QUARRYING.—XXI.

BY GEORGE GLADSTONE, F.C.S.

COPPER (*continued*).

PROPERTIES — ROLLING — HAMMERING — WIRE-DRAWING — PLATING—ALLOYS—SALTS OF COPPER.

PURE copper is easily recognised by its red colour, which is so familiarly known as not to need description; there is, indeed, no other simple metal with which it can be confounded. It is capable of receiving a high polish, but does not retain its brilliancy long, as it is liable to be affected by the atmosphere, under the influence of which it turns green, or a dark brown. This circumstance detracts considerably from its utility, except when combined with other metals which reduce its liability to tarnish. It melts at about 2000° Fahrenheit. It expands but slowly under the influence of heat; the calculation being that its linear expansion between the temperature of ice and that of boiling water amounts to $\frac{1}{552}$. Its power of conducting heat is, however, about $2\frac{1}{2}$ times that of iron. Its elasticity is only slight; but it is very tenacious, and can therefore be rolled or hammered out into thin sheets, or drawn into fine wire; and it becomes harder under these processes.

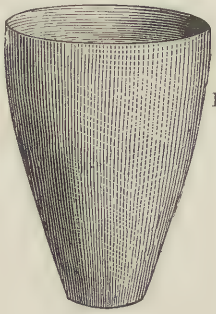


Fig. 1.

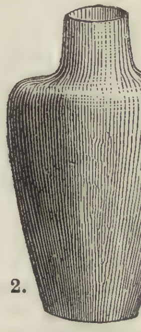


Fig. 2.

On account of its high value, it is never used in an unmixed state for large works; but it is applied to a great variety of purposes, in which its special advantages outweigh the question of cost. Some of these must now be briefly alluded to.

The bottoms of ships are sheathed with copper, or an alloy of this metal, for the purpose of protecting them from the attacks of worms, which would otherwise bore holes in the wood; as well as from barnacles, which would attach themselves to the surface. The former would impair the strength of the vessel, and cause her to leak; the latter would interfere with her sailing powers by preventing the free passage of the hull through the water. The gentle corrosion of the copper caused by the sea-water prevents any of these creatures from adhering to it. In making the sheathing the metal is rolled out into large sheets between heavy cylinders driven by steam. The cakes of copper while red-hot are passed between the first pair of rolls, and are then re-heated before the second rolling, and so on, until the plate has acquired the thinness desired; each successive pair of rolls being set closer together than the preceding. During these successive heatings the copper becomes oxidised on the surface; to free it from which it is dipped into a bath of urine, then heated afresh, and while hot plunged into a tank of cold water. The ammoniacal salts, having entered into combination with the oxide, form a scale, which is detached by the water, leaving the surface of the metal quite bright.

Fig. 3.

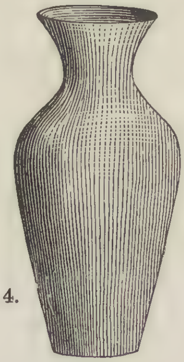


Fig: 4.

Copper sheets, thinner than those used for marine purposes, are sometimes employed in roofing. The spires and roofs of old churches and other public buildings are not unfrequently to be seen coated with copper, which may be recognised by its dull greenish hue; but this application is passing out of date, as lead, zinc, and tinned or galvanised iron are found to be more economical.

Many vessels used for culinary and manufacturing purposes —such as moulds and stewpans, urns and kettles, stills and coppers—are made of hammered metal. For making such articles a circular sheet of copper of the required diameter and thickness is taken, and beaten on one side until it assumes a hollow conical form; and by continuing the hammering on the inner side it can be beaten out to almost any shape that may be desired. From time to time the metal has to be warmed or annealed in order to prevent its becoming brittle; and this has to be attended to all the more carefully as the work proceeds, as the tendency to brittleness increases the longer the hammering is carried on. Figs. 1, 2, 3, 4, in the accompanying illustration, will serve to illustrate the intermediate forms assumed by a flat disc of metal under the hands of a workman in hammering it out into the shape of a vase. In this manufacture it is highly important to test the copper to see whether it contains any, or what foreign ingredients, as some of those which are commonly found in it greatly affect its malleability. Thus antimony and arsenic are highly objectionable, even when present in very small quantities; silver, on the other hand, is rather beneficial than otherwise. A careful chemical analysis should be made, as small quantities of tin, iron, and other metals besides those above named, may often be found in merchantable copper.

The tenacity of this metal renders it very suitable for wire-drawing; and this application of it may be found in almost every household, bell-wires being usually made of copper. In drawing it out, the same tendency to become hard and brittle is experienced, as when under the action of the hammer; it is, therefore, necessary to anneal it from time to time during the manufacture, in order to restore its softness and toughness. In making very fine wire the heat of a flame from burning straw is sufficient for the purpose.

Copper wire has within the last few years received other very important applications, on account of its high power as a conductor of electricity. As compared with silver wire, which is the best conductor known, and is therefore taken as the standard, it ranks as 94 to 100; none of the other metals can at all compare with these two in this respect. Only the very purest copper should be used for this purpose, as the smallest admixture of alloy or other foreign matter greatly interferes with its efficiency. In its application as telegraph wires there are several other reasons why none but the very best material should be employed; such as the immense length to which the wires extend, and the importance of rapidity of action, and of sensitiveness, in order to economise the electric power. According to the very careful experiments of Sir Charles Wheatstone, a copper wire will transmit electricity at the rate of 288,000 miles per second; but in practice nothing like this speed can be attained, as the insulators and the medium through which the wire passes become affected by induced currents, which cause a loss both of speed and power; the inferior conductors being still more liable than copper to suffer from these causes.

The same principles which suggest the use of copper wire in telegraphy also indicate the propriety of using it as a protection against thunder-storms. In shipping, where lightness as well as efficiency has to be studied, this metal is always employed. A thin strip or wire is carried up to the masthead, which by its superior conductivity will effectually protect the mast from the effects of the lightning, and that without risk of being fused by the electricity; its power of resisting fusion being in proportion to its power of conduction.

Silversmiths very frequently make use of copper as the foundation of their manufactures, and then coat the goods over with a thin film of the more valuable metal. This is done by rubbing it over with a composition made of nitrate of silver, chloride of sodium, and the acid tartrate of potash, when a

decomposition of the former salt takes place, and a film of the metallic silver is deposited upon the surface of the copper. A heavier plating is made by a mechanical process. A sheet of silver is laid upon one of copper, a little powdered borax being placed between them; they are then heated in a furnace nearly to the melting-point, and while in that state are passed between heavy rollers, which bring the surfaces of the two metals into actual contact. These plates, consisting of copper on the one side and silver on the other, are then worked up into various useful articles for the table.

Copper was formerly used in making our coins of the lowest denominations, until superseded by the bronze coinage; but it also finds its way into the gold pieces, a certain per-centage of copper being mixed with the precious metal to give it increased hardness. Our standard gold contains 8·33 per cent. of copper. The red gold of jewellers is still more highly alloyed with it; sometimes to the extent of 25 per cent.

Copper forms the principal ingredient in several alloys of very considerable value for industrial purposes. The various combinations of this metal with tin have already been described in Article XVII.; while those with zinc will form the subject of the next paper. Those with nickel, lead, and other metals, will be described hereafter when treating of those different elements. Sometimes it is mixed in small quantities with iron; the addition of about 5 per cent. of copper to grey pig-iron yields an alloy of very considerable hardness, which is therefore recommended for anvils, and other implements which have to endure rough usage.

Phosphorus also forms some definite chemical combinations with copper. It yields two phosphides, the one containing six equivalents and the other three equivalents of copper to one of phosphorus; giving 14·1 and 7·5 per cent. of the latter element respectively. Both these alloys are very hard and brittle, with a crystalline structure; but if the proportion of phosphorus be reduced to about 1½ per cent., just the opposite effect is produced. This compound is much more readily fused than pure copper, becomes very limpid, and makes excellent castings when poured into chills or iron moulds. It greatly contracts in cooling, and can only be rolled and hammered when cold. It will endure a weight more than 50 per cent. greater than pure copper, without breaking; being in this respect superior even to gun-metal.

It will now only remain to consider the principal salts of copper of importance in the arts. Their uses are so varied that they will continually be found mentioned in other series of articles, such as those which treat of glass-making, colours, dyeing, alum, and many others.

The manufacture and uses of verdigris, or the basic acetate of copper, have been described under the article "Acetic Acid" ("Chemistry applied to the Arts."—XV.), to which the reader is referred. The normal acetate, $CuC_2H_3O_2$, sometimes called crystallised verdigris, is produced by taking some of the ordinary verdigris, or some of the oxide of copper, and dissolving it in acetic acid. It can also be made by precipitating a solution of acetate of lead with sulphate of copper. The salt is poisonous; a common characteristic of all these compounds, the best antidote for which is white of egg or albumen.

The *sulphate* ($CuSO_4 + 5$ water) is more familiarly known as blue vitriol, and is very extensively used in making both blue and green pigments, as well as in electrotyping, and in medicine; it possesses highly astringent properties. The water pumped up from the bottom of copper mines often consists of a solution of this salt, but it is always charged with impurities. The commercial article is most generally made in one of the following manners. Old copper is taken and heated to redness in a reverberatory furnace, after which some sulphur is thrown in and the doors closed, when combination of the two ingredients takes place, and the metal is converted into a sulphide. On admitting the air this is again changed into a sulphate, along with some oxide. The charge is then thrown while still hot into water containing some sulphuric acid; and it is then evaporated down so as to crystallise out the sulphate of copper. It may also be made by the roasting and lixiviation of the common pyrites, the sulphide of copper and iron; but it is liable to be contaminated with a little of the sulphate of the latter metal. This, however, can readily be separated by the application of a small quantity of nitric acid. A very pure salt may also be made by boiling the oxide with dilute sulphuric acid, and then allowing the liquid to cool, when the sulphate of copper will crystallise out; or by heating metallic copper in presence of strong acid, and digesting the resulting mass with hot water, which dissolves out the sulphate of copper, from which crystals of the salt are thrown down as it cools. The former of these methods is commonly adopted in manufactories. Strong wooden tanks lined with lead are used for the purpose, and the boiling is caused by forcing steam in through a lead pipe near the bottom of the tank. From this the liquor is driven off into other leaden vessels to crystallise out, which occupies from five to six days. After being drained dry from the mother liquor, the crystals are packed in casks for sale.

The arsenite of copper, commonly called "Scheele's Green," is prepared by precipitating a copper salt, such as the foregoing, with arsenite of potassium; or with arsenious acid itself, neutralised by ammonia.

The aceto-arsenite of copper is also used as a pigment, under the name of "Schweinfurt Green." It produces a splendid colour, but it has a bad reputation on account of being a highly poisonous substance, though it is not volatilised at any ordinary temperature. It is made by taking 5 parts of verdigris or the acetate of copper, making this into a paste, and then boiling it up in an aqueous solution of arsenious acid, containing at least 4 parts of acid to 50 of water. If it should turn a yellowish-green during the process, it indicates a deficiency of acid, which must be increased, and the boiling continued for a short time longer, until the full colour has been attained.

Azurite, or the blue carbonate of copper, which has been already described when speaking of the different kinds of ores, is made into a pigment, by grinding it into a fine powder. It goes by the name of "blue verditer;" but its value in the arts is impaired to some extent by its liability to turn green on exposure to the influence of the atmosphere. It can also be made artificially. The simplest process is that of working up a quantity of chalk or carbonate of lime with a solution of nitrate of copper, when double decomposition takes place, forming nitrate of calcium and carbonate of copper. The latter settles to the bottom, and is washed with water several times till quite pure. Before the precipitate is dried, from 8 to 10 per cent. of caustic lime is added, and intimately mixed with it, when the compound acquires a beautiful blue colour, and the process is complete.

The more usual plan is to grind up a quantity of the sulphate of copper, along with a slight excess of chloride of sodium, into a fine powder, and then work them up into a paste with water. Into this small bits of thin sheet-copper, which have just been thoroughly purified from any oxide by first dipping them in acid and then washing them with pure water, are inserted; the weight of metal employed should be about equal to that of the sulphate used in making the paste. The copper is left in the paste for about three months, but in order that all parts should be equally acted upon, the whole contents of the chest are turned out and then back again about once a week. The product of this operation is carefully washed with water, and then treated with hydrochloric acid, in order to convert it into a soluble chloride of copper, from which it is again re-converted into the oxide by the agency of caustic lime. The precipitate is subsequently washed and filtered, and then laid out to dry in the air, but the temperature should not be allowed to exceed that of ordinary summer weather. When thoroughly dry the product will possess a beautiful blue colour.

CHEMISTRY OF THE FINE ARTS.—VII.

By Professor CHURCH, Royal Agricultural College, Cirencester.

THE RESTORATION AND PRESERVATION OF MURAL PAINTINGS—CHEMISTRY OF THE MATERIALS OF SCULPTURE AND ARCHITECTURE—MOSAICS—MARBLE—STONE, BRICK, AND TERRA-COTTA—WOOD.

IT is often desirable to preserve, for artistic or archæological reasons, the remains of those mural paintings with which, in mediæval times, our English churches were so profusely decorated. But great difficulties generally stand in the way of such preservation. Sometimes the plaster below the painting is in a thoroughly decayed state, crumbling on the slightest pressure, and in some cases the weakness is apparent in the

layers of pigment themselves. Under the former conditions the only process of conservation involves the entire removal or transference of the painting to canvas or cloth: in the latter case, where the plaster is sound but the pigments loose, there is no plan which answers more thoroughly, and is easier of execution, than that of fixing the crumbling paint by means of a spray of some preservative solution. Before giving details of the successful application of this process, we must recur for a brief space to the process of transference before mentioned. When a mural painting has been cleared of the layers of white-wash which concealed it, and shows a good firm surface, though the plaster below is uneven and crumbling, it may, after careful dusting, be gradually transferred to a piece of cloth, which is to be wetted with smooth flour-paste just as it is gradually applied to part after part of the surface of the picture. Other materials of an adhesive nature, such as resin, have been employed for this purpose with success. When the cloth or canvas is quite dry, it may be loosened, together with its adherent painted layer, by the insertion of appropriate instruments (palette knives, etc.) between the layer to be removed and the plaster below. The other operations necessary to restore the picture are of a simple mechanical nature, involving the preparation of a bed of fresh plaster for its reception, and the final removal of the cloth on the face of the work by means of hot water. It may then be allowed to dry thoroughly, and finally submitted to the following treatment, which is equally appropriate in those instances where the paint on the surface is in a powdery and fragile condition, though the wall behind remains sound. All dust must be first removed by the bellows, or by a soft brush if the picture will bear it. Then the surface is to be dried, by means of a brazier or by burning spirit of wine upon it, but slowly and carefully, so that no flakes of colour curl up and separate. While still warm the surface is to be syringed (by means which we have pointed out in our remarks on Stereochromy) with a preservative liquid. A good preparation for this purpose is the wax or paraffine medium described in the last lesson. This material requires to be diluted with a good deal of the proper solvent (benzole or turpentine) before it is used for syringing. The liquid spray as it dries up fixes the loose particles and flakes of paint to each other and the wall, and though it darkens the colours a little, enriches them somewhat at the same time, while it exerts, it must be allowed, an unsatisfactory effect upon the whites and high lights of the picture. Preparations of parchment size or isinglass may be similarly employed in lieu of the paraffine or wax medium, but in a damp position these substances are likely to introduce a new element of decay, as they favour the growth of mildew upon the surface to which they have been applied. Nor is it usually safe to apply any preparation of the soluble silicates to an ancient mural painting executed in tempera or fresco, though such a proceeding has been once and again recommended. In trials made by the author of these papers it was found that water-glass solution produced the most undesirable changes of colour and surface in some fragments of mural decorations to which it was carefully applied. The process which we have described and recommended, and in which a spray of a chemically inert solution of paraffine or wax and resinous substances is used, seems to leave very little to desire. In some cases, where the colours and surface of the painting are firm and good, it may be simply painted over with a soft broad brush with such solutions as we have named. A simpler liquid preparation may even be used, of which paraffine and mineral turpentine are the sole constituents.

In now turning our attention to mosaic and tessellated work, we would first notice an erroneous idea which seems to prevail widely on the subject of the permanence of works executed in this manner. In wall and floor mosaics materials of very different degrees of texture and stability were and are employed as tesseræ—the little cubes or angular masses which constitute the materials at the disposal of the mosaicist. These coloured substances are either natural stones and marbles, or preparations of burnt clay or terra-cotta, or true porcelain, or else glass and enamel. While some of the natural stones and marbles of the most compact and insoluble kinds are but little influenced by damp and air, other sorts of an absorbent or mixed nature are very liable to disintegration and decay from frost and adverse atmospheric agencies. The older pottery tesseræ are not usually satisfactory, owing to their porous texture and the comparative ease with which they relapse into a soft mass not unlike the original clay from which they were made. The more modern tesseræ are of a much improved nature, especially those manufactured from nearly dry clay intensely compressed before burning. But the tesseræ of the hard porcelain, containing neither bone-ash on the one hand, nor excess of alkali on the other, leave nothing to desire in point of hardness and permanence, while they may be stained throughout their substance or near their surfaces only by those metallic oxides which are employed in glass and porcelain painting. Of the glass and enamel tesseræ a less satisfactory report must be given. The materials of which they are composed are generally remarkable for the quantity of alkaline and lead compounds which they contain. The carbon dioxide (carbonic acid) of the atmosphere acts upon these substances, in the course of time producing either a flaking off of the material itself, or else an incrustation upon its surface. No better illustration of this fact can be given than that afforded by the beautiful ruby glass which was occasionally employed in the Roman tessellated pavements found in this country. The tesseræ made of this glass are covered with a crust of green carbonate of copper and white carbonate of lead arising from the action just named. Thus the colour they now show is scarcely that which they were used to represent by the original artists. In the well-known and beautiful pavement at Corinium (Cirencester), the red poppies in the hair of Flora, and the blood dropping from the wounds of Actæon are of a malachite green. The very iridescence which often renders ancient glass so exquisitely beautiful is of itself no doubtful sign of decay. Film after film of the glassy surface becomes minutely streaked and pitted by the gradual removal of the alkaline bases of the vitreous material, until at last the whole substance of a vase, perhaps a quarter of an inch thick in parts, crumbles under the fingers to a mass of rainbow-tinted films. Enamels are no better than glass in this respect, often containing as they do still larger proportions of those constituents which aid in the process of decay. The oxide of tin which is introduced into them to confer opacity, exerts little or no favourable influence on their preservation, though in itself unalterable. We fear that we shall soon have evidence—in the fate of some mosaics recently executed in this country, and placed in positions where they are exposed to the weather—of the changes to which the apparently lasting materials of such works are really liable; and we must mention another matter in relation to mosaic work which hardly seems to have attracted attention. What guarantee have we of the permanence and continued binding power of the cement with which each tessera is held in its place? Without entering into details about such cements, which would indeed involve us in too long a digression, it may suffice to remark that the pure slaked but still caustic cream of lime which the Romans used for this purpose generally remains perfectly hard and firm after the lapse of 1,600 or 1,700 years. And it is reasonable to anticipate that if a hard and insoluble cement be once secured, it would be an admirable plan to saturate it when dry with a small quantity of pure and unalterable white paraffine, which might readily be driven by the aid of heat into the surface of the finished mosaic picture. A similar plan has sufficed in the hands of the author to restore to brilliancy, to waterproof, and to preserve from further change some fragments of Roman tessellated pavements which were rapidly falling to pieces.

The saturation of marble, especially of white statuary marble, with purified beeswax is an ancient practice which has been revived in modern times with some measure of success. But the bas-reliefs of the Wellington arch by Apsley House, which were thus treated under the direction of Faraday, and with every care, such as previous drying and warming, have not been able to resist very long the corrosive influence of a London atmosphere charged highly with the acid products of the combustion of coal. There can be no doubt that solid paraffine similarly used for the saturation of the marble would have exercised a much more lasting, if not a completely permanent effect. We have said enough in preceding lessons as to the selection and solution of the paraffine to be employed for such purposes as the present. Here, however, it may be convenient to note that it may be applied to stone not only in solution, but also in the state of fine powder laid on with a little water as a kind of paste, then allowed to dry, and finally driven in by the

aid of heat. If it be desired to tint the marble, this may be done by previously incorporating the necessary pigment with the paraffine employed. This process is applicable not only to statuary marble, but to stone, wood, and many other materials. In the case of a font of alabaster which was gradually being dissolved away and corroded by the solvent action of the water in it, this fatal action was arrested by saturating the interior of the bowl with a fine coat of paraffine by means of heat. For decayed stonework and marble in ancient buildings the paraffine process forms perhaps a more complete and safe preservative than any of those numerous and varied aqueous solutions which have from time to time attracted public notice. It is also peculiarly adapted to the preservation of metallic surfaces from rust and corrosion; and in the case of iron objects of early date it has been used with great success by the author for many years past to preserve them without further alteration or disruption. For this purpose it is best to dry and warm the objects to be coated; they are then to be suspended in pure melted paraffine at a temperature of about 120° Centigrade, till all bubbles of vapour have ceased to be given off. The objects when lifted out and allowed to drain and harden will no longer admit of corrosion, while the scales or fragments of which they consist will be cemented together.

In default of any perfect process of waterproofing and hardening brick, terra-cotta, and stone, we may direct attention, though in a very brief manner, to that one method of which the writer of these papers has had most experience, and which indeed he gradually elaborated by experimental trials on public buildings. This process consists in the successive application of three solutions to the material to be waterproofed and hardened. Solution No. 1 is one of pure hydrate of baryta; No. 2 contains monocalcic phosphate, or soluble phosphate of lime; and No. 3 is a double water-glass mixed with some quantity of a dialysed solution of pure silica. Solutions 1 and 2 are applied alternately many times until no more can be absorbed; then, after a lapse of a day or so, one or two coats of No. 3 are given. The great feature of this process lies in the entire absence of any soluble salt. No such compound is formed in consequence of the changes which go on between the solutions themselves or between the solutions and the stone, etc. The surface of the stone is rendered smooth and slightly translucent in appearance, but is not discoloured, except it be of dark tint originally. In such a case, and where brick has to be treated, some suitable pigment, any of those which may be employed in stereochromy, should be mixed with the last coat of No. 3 solution just before it is laid on. Not only have brick walls and chimney stacks in the neighbourhood of the sea been rendered waterproof by this process, but it has been employed in the interior stonework of public buildings for the purpose, on the one hand, of preventing the soiling of stone by grease, soot, and clothes, and, on the other hand, for preventing the stone itself from being abraded by friction, and coming off in powder upon objects which may touch its surface. The drawback of the process is the tedious series of applications of three liquids which it involves. Neither water-glass, nor hydrofluosilicic acid, nor phosphoric acid, nor any of the other preparations which have been used or suggested for the purposes of preserving stone, actually fulfil the necessary conditions of success, as they are either ineffective, or else injure and disfigure the surfaces to which they are applied. A great desideratum would be supplied if a hardening, preserving, and waterproofing preparation could be obtained, which in one operation, or at all events by its use in the form of a single fluid only, could be readily applied to our stone and brick buildings. It must not discolour them, nor must it be of the nature of a paint. A solution of this kind is necessary in some places and under certain conditions, not only for stone, but also for terra-cotta. It is a mistake to suppose that this substance is practically impenetrable even when made of a satisfactory clay, well burnt, and with the kiln-face left untouched. Saline efflorescences and frost may exert upon it, as upon all materials not destitute of porosity, the most injurious disruptive influence. Under such circumstances it is of little use coating the surface with a repellant and waterproofing material; the sides and back of each block must be similarly treated before they are placed in position, that the entrance of the injurious liquids, etc., from behind may be effectually prevented. For the same reason the proper treatment of damp walls is seldom hit upon. And here another difficulty presents itself: the ashes used in the preparation of the plaster and mortar of such walls, instead of being clean and fresh, have often been used previously as absorbents of various decaying matters of animal and vegetable origin, and have become charged with the nitrates and sulphates which occur amongst the decomposition products of such matters. Where such ashes have been used in plaster, the task of rendering the wall sound and free from efflorescence is almost hopeless. Coating it with a water-glass cement after a thorough cleansing with warm rain-water has been attended in some cases with fair success.

Though there is no doubt that in many directions, not noticed in these papers, chemistry has rendered service to the fine arts, or is capable of doing so, yet we trust that the facts and suggestions which we have laid before our readers, even if incomplete, will yet aid those who work with the beauties of form and colour. It is certain that science and art will each benefit by a legitimate union.

SHIP-BUILDING.—XI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF WOOD AND COMPOSITE SHIPS (*continued*).

In the preceding paper the disposition and fastenings of a wood skin, formed of one thickness of plank, were described at length, that being the common plan: we will now proceed to notice an arrangement where the skin is made up of three thicknesses of plank, as shown in Fig. 31. The planks in the two inside thicknesses, B, C, will be seen to be placed diagonally and to cross each other at right angles, whilst the outside layer, A, is worked longitudinally. With a skin so formed there is obviously no want of resisting power against strains tending to cause longitudinal sliding or shearing, such as exists in the skin of an ordinary wood ship. In fact, we have here a wood skin capable of transmitting and resisting strains in all directions, and requiring much less stiffening and framing than an ordinary skin. The system of construction is commonly known as the "diagonal" or "bread-and-butter" system. It has been used in many cases where the chief object has been to combine lightness with strength to an exceptional extent. The royal yacht *Victoria and Albert* and several of the light swift vessels of the Royal Navy have been constructed on this plan, as have also many merchant vessels, and it has given great satisfaction after full trial.

The framing in vessels built on the diagonal system is much lighter than that of ordinary ships. The middle-line arrangements are in some cases very similar to those previously described, but there are generally no timbers standing upon the floors, so that the spacing of the frames above the floor-head is much greater than in the usual plan. In other cases the frame is still further lightened, and iron braces are used to strengthen the skin. The work of building is no doubt made more difficult by adopting the diagonal arrangement, and this fact probably accounts for the comparatively limited use made of it. A skin so formed also requires great care in its fitting and fastenings. When the first layer of diagonal planking has been worked, it has to be secured to the timbers by a few fastenings, and lightly caulked before the second layer can be brought on; and this in its turn has to be secured to the timbers as well as to the inner layer, and caulked before the longitudinal planking can be fitted. All three thicknesses are ultimately bound together by through-bolts clenched inside and outside, and are secured to the timbers by metal screws, dumps, or through-bolts. But when properly fitted and fastened the united layers form a thoroughly efficient skin, and with comparatively little weight give great strength of hull.

Large boats for the Government service are commonly built upon a plan slightly differing from that illustrated in Fig. 31. Their skins are formed of two thicknesses of planking, wrought diagonally just as B and C are in the diagram. Their only framing consists of light floors stretching out to the bilge, and yet so great is the strength of the skin that they are found capable of bearing rough usage and carrying very heavy weights, without any sensible change of form or other serious damage. It should be added that in building these boats the planking is wrought upon a light framework of suitable form, capable of being removed with ease when the work is sufficiently advanced.

A few light river steamers have been built with one thickness of planking, the strakes of which were worked longitudinally as on the ordinary plan, and connected together by numerous edge-bolts. Frames were almost entirely dispensed with, strong diagonal iron riders and straps being employed to strengthen the skin. This plan is said to have answered fairly in the vessels so built, but it scarcely appears capable of successful application in sea-going vessels, which are necessarily subjected to much more severe strains than those river steamers have to bear.

Considerable importance attaches to the *caulking* of the skins of wood ships, and a few words respecting it will not be out of place. The operation consists simply in driving threads of oakum, the number of which varies with the thickness of the planking, into the spaces between the edges and butts of adjacent planks. These spaces or "seams" should be so formed as to taper gradually toward the inner surfaces of the planks, where the adjacent edges should touch each other; and when the oakum is driven in the seams should be compactly filled and made water-tight. The latter object is partly attained by "paying" over the seams with pitch after the oakum is in place. Pieces of plank are sometimes cut out at different parts of the bottom of a ship in order to test the efficiency of the caulking. However tightly the oakum may have been driven at first, it will probably become slack after a vessel has been a few years at work, this slackness being due in part to shrinkage in the planking, and in part to the unavoidable working of the vessel when at sea. One of the most common features in the refit of wood ships is consequently the re-caulking of their bottoms, which renders them not only tighter, but also stronger.

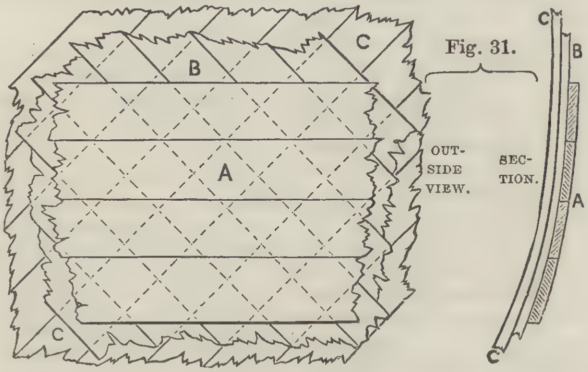


Fig. 31.

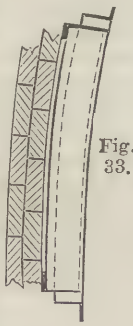


Fig. 33.

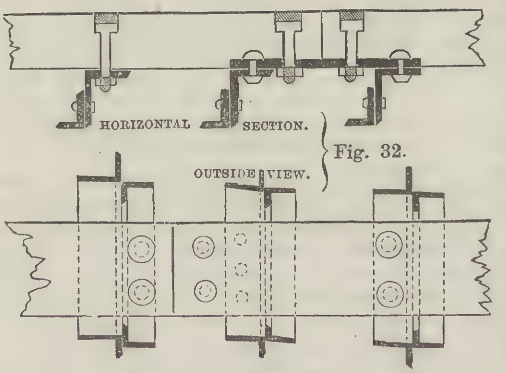


Fig. 32.

Turning next to the skins of composite ships, it will be proper to take first the most common arrangement where the planking is in one thickness. So far as the general disposition and the shift of butts is concerned, there is no difference between this plan and that illustrated by Fig. 27, page 256. Three passing strakes occur between consecutive butts, and "steps" are carefully avoided. Instead of being placed *upon* the frames, however, the butts are placed *between*, and usually secured as shown in Fig. 32, a plate of iron, termed a "butt-plate," being riveted to the adjacent frames in order to support the butt and receive its fastenings. This plate is of the same breadth as the planks it helps to connect. Each butt-end is secured by two bolts, with nuts hove up, inside the butt-plate, on screw-threads cut for that purpose. The heads of these bolts are formed as shown to give good holding power, and are sunk into the planking, so that they may be covered with wood plugs. Great care should be taken in driving the bolts and fitting the plugs in order to make the bottom tight. The sketch shows also how the planking is secured to the frame angle-irons, by means of nut-and-screw bolts similar to those at the butt, the nuts being hove up inside the flange of the angle-iron. Double fastening is shown in this case, and it is that suggested by Lloyd's Committee for planks more than 10 inches broad; double and single fastening alternately would be allowed in planks from $8\frac{1}{2}$ inches to 10 inches broad, and single fastening in planks under $8\frac{1}{2}$ inches in breadth. In all cases, however, double-butt fastenings like those in Fig. 32 are required; and it will be clear that this method of securing the butts gives greater strength against tensile strains than that usual in wood ships. The butt-plate, in fact, straps or "fishes" the butt in a far better way than the frame-timber of a wood ship; and the butt-bolts are better arranged in the composite skin. But even with this improved connection it cannot be expected that a butted-strake, such as is shown in Fig. 32, can be thoroughly efficient against severe tensile strains, the ultimate effect of which would undoubtedly be to open the butt by tearing away the short-grained wood left between the bolts and the butt. It should be added that in some few composite vessels butt-plates have not been used, but plain scarfs employed instead of butts, in order to make a good connection.

Composite ships with one thickness of planking obviously require to be strengthened by diagonal ties on the frames, just as wood ships require diagonal riders. The usual plan is to have two sets of diagonal tie-plates riveted upon the outside of the frames, and crossing each other at right angles. The upper ends of these tie-plates are connected with a strake of plating, named the "sheer-strake," fitted in wake of the upper deck beams, and their lower ends are secured to a strake of plating worked near the bilge at the height where the floor-plates end. By this means the skin is much aided in resisting longitudinal sliding or shearing, against which the caulking, when tight, is also a great help.

The composite system was devised in order to combine greater strength than wood ships possess, with an equal freedom from foulness of bottom, and for the latter purpose metal sheathing, usually of copper or Muntz metal, is nailed to the planking up to a few feet above the load water-line. It has already been remarked that the great danger incurred by this plan is the setting up of galvanic action between the metal sheathing and the iron portions of the hull, which action necessarily leads to the more or less rapid deterioration of the iron. Experience proves that even with the greatest precautions it is difficult to avoid metallic connection between the sheathing and the iron portions of the hull, especially when only one thickness of planking is used; and in cases where less care is taken the damage to the iron is often both serious and rapid. For example, it is very common to use iron bolts in fastening the planking, their surfaces being often "galvanised" or coated with zinc to protect them from rust, and their heads let into the planks and covered by plugs, as shown in Fig. 32; and in such cases the wasting of the bolts to a very serious extent is not at all unusual after a short period of service. Copper or metal bolts are sometimes used instead of iron, and are, on the whole, much to be preferred; but they are not free from disadvantage, because, as usually fitted, they form a direct metallic connection between the sheathing and the iron frames, and may cause damage to the latter; besides which they are much more expensive than iron. In fact, after full trial, many ship-builders have formed the opinion that it is necessary to employ two thicknesses of planking in the skins of composite ships with copper or metal sheathing, in order to prevent serious galvanic action and to secure proper durability. Others have advocated the disuse of such sheathing, and the substitution for it of zinc, urging that the bottoms would thus be kept clean, while no evil would result to the iron portions of the hull if galvanic action

were set up, the zinc sheathing then wasting instead of the iron, and being easily replaced. The balance of opinion appears at present to be in favour of the continued use of metal sheathing, and we will therefore glance at some of the arrangements adopted when the skin planking is worked in two thicknesses.

One of the most common plans is illustrated in Fig. 33; both thicknesses being worked longitudinally, and the seams of the planks in one layer being brought upon the centres of the planks in the other layer, the two sets thus mutually supplying the direct edge connection which is wanting in a wood skin worked in one thickness.

Another arrangement consists in working both layers of planking diagonally (like B and C in Fig. 31). Diagonal tie-plates are not fitted on the frames when this plan is followed, and they are obviously unnecessary, the skin being capable of acting alone in resisting longitudinal shearing strains.

Still another plan consists in working one layer (either the inner or outer) diagonally, and the other longitudinally; in most cases the outer planks are worked longitudinally. In all three plans both thicknesses of planking must be caulked, and between the two it is usual to fit felt, waterproof glue, or some similar material. The inner thickness is fastened to the frame angle-irons by iron nut-and-screw bolts; and the outer thickness is secured to the inner by short copper or metal bolts, either with nuts on the inner ends or clenched upon rings on the inside of the planking. The fastenings of the outer thickness are placed in the frame-spaces, clear of the frames and the fastenings of the inner thickness, so that the probability of any galvanic action being set up between the metal sheathing and the iron frames, etc., is much reduced. The cost of building a vessel with two thicknesses of planking is of course greater than that of building with one thickness; but there is reason to believe that the additional outlay is more than repaid by the increase in durability and efficiency.

It is usual to have the garboard strakes in one thickness, even when the greater portion of the skin is in two thicknesses; and it is by no means uncommon to terminate the double thickness at a moderate height above the load water-line of the vessel, the remainder of the upper works being covered with one thickness of planking. The latter practice has no such attendant disadvantages as the use of a single thickness under water entails, and it lessens the cost of construction. In some cases this topside planking is replaced by iron plating down to six or eight feet from the load line, but this is not a common plan, nor does it seem on the whole preferable to the other.

Some eminent authorities have expressed great doubts as to the efficiency of the skins of composite ships, and the general strength of their structure. As compared with the skins of iron ships, those of composite ships are undoubtedly inefficient against some classes of strains; but they compare favourably with those of wood ships, especially when wrought in two thicknesses. Severe and extended trials have, moreover, shown that composite ships are fully capable of resisting the strains brought upon them when at sea; and the fact that the far-famed China tea-ships which race home yearly under an enormous spread of canvas, continue to perform their duties satisfactorily without displaying signs of working or weakness, furnishes a very strong argument in favour of the sufficiency of the strength of composite ships. In short, their continued use or their disuse is likely to be settled rather by considerations of cost and durability than by those of structural strength.

The arrangements of the inside planking or ceiling of composite ships are identical in character with those of ordinary iron ships, and it will consequently be preferable to defer any remarks on that subject to a later paper.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVI.—DAVID MUSHET.

BY JAMES GRANT.

Though the existence of ironstone in the Scottish coal measures was known for many years before the year 1760, when, as we have related in the memoir of Dr. Roebuck, the Carron works were established, no attempt was made, until then, to turn it to account. Only one kind of ironstone was then used, viz., the argillaceous, or "clay-band;" for the more valuable and carbonaceous was unknown until the year 1801, when it was discovered by David Mushet, a native of the little town of Dalkeith, six miles from Edinburgh. He was born there in 1772, and though but the son of a labouring man, was descended from an old historical stock, the Mushets who resided in Kincardine, on the estates of the Montrose family. In the time of Charles II., all these Mushets, save two, perished of the plague, and one of these, the Rev. George Mushet, who accompanied the great Marquis of Montrose in nearly all his campaigns as chaplain, died early in life, and is buried in the churchyard of Kincardine; but the name can be traced far back in Scottish history, as they are descended from William de Montefixo, who held the lands of Uchreardore under Robert I., and others in the thanedom of Cluny under David II.

At the age of nineteen, David Mushet, who like most of his family had been brought up as a metal founder, obtained employment at the Clyde Iron Works, near Glasgow, as accountant of the company, which had then but two blast-furnaces at work. Though he had nothing to do with the mechanical operations of the firm, being of a thoughtful and speculative turn of mind, the remarkable conversions undergone by iron in the various processes of manufacture soon began to occupy his attention, and he joined in the occasional discussions of that subject held by the more intelligent of the young men employed about the works, and Fourcroy's book was frequently referred to by them with reference to certain questions of difference which arose among them in the course of their inquiries.

In 1793, when the establishment of the company was reduced, David Mushet finding that he was almost the only occupant of the office, resolved to commence a few experiments, and to acquire a perfect knowledge of assaying as the true key to the method of iron-making. "He first set up his crucible upon the bridge of the reverberatory furnace used for melting pig-iron," says Mr. Smiles, "and filled it with a mixture carefully compounded according to the formula of the books; but notwithstanding the shelter of a brick, placed before it to break the action of the flame, the crucible generally split in two, and not unfrequently melted and disappeared altogether. To obtain better results, if possible, he next had recourse to the ordinary smith's fire, carrying on his experiments in the evening after office hours. He set his crucible upon the fire on a piece of fire-brick, opposite the nozzle of the bellows, covering the whole with coke, and then exciting the flame by blowing. This mode of operating produced somewhat better results; but still neither the iron nor the cinder obtained resembled the pig or scoriæ of the blast-furnace, which it was his ambition to imitate. From the irregularity of the results, and the frequent failure of the crucibles, he came to the conclusion that either his furnace or his mode of fluxing was in fault, and he looked about him for a more convenient mode of pursuing his experiments. A small square furnace had been erected in the works for the purpose of heating the rivets and for the repair of the steam-engine boilers. The furnace had for its chimney a cast-iron pipe of 6 or 7 inches in diameter, and 9 feet long. After a few trials with it, he raised the heat to such an extent that the lower end of the pipe was *melted off*, without producing any very satisfactory results on the crucible, and his operations were again brought to a stand-still."

For two years Mushet continued to make experiments in the art of assaying, and during that time he wrought entirely in the method detailed by past experimentists in their books; but certain that all his results were somewhat negative, he cast books aside, and resolved to work upon a system of his own, the result of which, he was assured, would be similar to those produced by the blow-furnace. All these repeated attempts had to be made in the night, as all the hours of the day were fully occupied by quill-work in the company's office; but he eventually succeeded, and he became acknowledged as a well-skilled assayer in iron, and whenever a difficulty occurred in the smelting of any new ironstone, "the manager himself resorted to the book-keeper for advice and information; and the skill and experience he had gathered during his nightly labours enabled him readily and satisfactorily to solve the difficulty, and suggest a suitable remedy."

He was now permitted by the company to have an assay-furnace of his own, at which he continued to make his experiments, while at the same time he instructed the son of the

manager in the art of assaying, devoting, at times, entire nights to experiments in assaying, in roasting and cementing iron ores and iron stones, decarbonating cast iron for steel and bar iron; working thus till three a.m., and leaving instructions with the engine-man to call him at half-past five, so that he might be at his desk by six!

In the midst of his arduous career of investigation, as he tells us in his "Papers on Iron and Steel," published in London in 1840, without any cause or motive being assigned, but probably through some whim or caprice, he was ordered to stop; and, by direction of the manager, his furnaces were demolished, with an edict that they were not to be erected again! This ended all his hopes of research at the Clyde Iron Works. However, he erected, with the consent of a friend, an assay and cementing furnace, on a piece of ground two miles distant from these works, and thither the unwearying Mushet was wont to repair in the night, and during the hours allotted by others to their meals, for a whole summer; but the labour proved too great, and the results too uncertain to be continued longer. At the close of 1798 he quitted the Clyde Works, and constructed several furnaces, and for two years continued his investigations in connection with the alloys of metals.

"Though operating in a retired manner, and holding little communication with others, my views and opinions," he relates, "upon the *rationale* of iron-making, spread over the establishment. I was considered forward in affecting to see and explain matters in a different way from others who were so much my seniors, and who were *content* to be satisfied with old methods of explanation, or with no explanation at all. . . . . Prejudices seldom outlive the generation to which they belong, when opposed to a more rational system of explanation. In this respect Time, as my Lord Bacon says, is the greatest of all innovators. In a similar manner *Time* operated in my favour in respect to the black band ironstone."

In the year 1801, when crossing a stream called the Calder, in Old Monkland, in the Middle Ward of Lanarkshire—a soil abounding in mineral treasures—Mushet picked up a specimen of this most valuable description of ore, which chanced to attract his eye as it lay in the bed of the river. He subjected it to his crucible, and on being fully satisfied as to its properties, he next proceeded to discover its geological position and relations, and finding that it belonged to the upper part of the coal formation, he designated it carboniferous ironstone; and he further discovered that rich beds of the mineral were in most of the western counties of Scotland. Analysis proved it to contain over 50 per cent. of protoxide of iron; while the coaly matter it contained was not its least valuable ingredient, as by the aid of the hot-blast it may be smelted without *any* addition of coal.

In the year of his discovery, Mushet was engaged in erecting for himself and his partners the Calder Iron Works, and great prejudice was excited against him by all the ironmasters at the time, for daring to class "the wild coals" of the country, as black band was called, with ironstone fit and proper for the blast-furnace. Yet that discovery enabled Scotland to take a high rank among the iron-working nations of Europe; and seams of the same coal have since then been discovered in North Wales and in Staffordshire.

From the establishment of the Carron Works in 1760 till 1788, the quantity of iron produced by Scotland did not exceed 1,500 tons per annum; but it has steadily risen since then, and the total quantity made in the year 1867 amounted to 1,031,000 tons; but ten years previous, the largest quantity of ore put out in one year was 2,500,000 tons. Now, thanks to the discovery of David Mushet, the west of Scotland, more particularly the district about Old Monkland, has made an unparalleled advance in population and prosperity. To this, of course, the introduction of the hot-blast and the increasing demand for iron for railway purposes have added. In that district which was once so pastoral and lonely, there is everywhere heard the brattling of machinery, the sonorous strike of mighty hammers, and the hissing and clanking of the steam-engine. Dense clouds of smoke roll over it incessantly; a coat of black dust lies over everything, and the flames of the blast-furnaces, for ever belching with wild and weird effect, but chiefly at night, have won for that district the somewhat appropriate title of "the Land of Fire."

"Fortunes have been realised there in the iron trade," says a statist, "with a rapidity equalled only by the sudden and princely gains of those who accompanied Pizarro to Peru. It is understood that the clear profits of a single establishment in this line during the year 1840 alone were £60,000; though less than twenty years previous the co-partners of this company were earning their bread by the sweat of their brow, in following the agricultural vocation of their fathers."

"Such," says Mushet himself, "are the consolatory effects of time, and the discoverer of 1801 is no longer considered the intrusive visionary of the laboratory, but the acknowledged benefactor of his country at large, and particularly of an extensive class of coal and mine proprietors and iron masters, who have derived, and are still deriving, great wealth from this important discovery, and who, in the spirit of grateful acknowledgment, have pronounced it worthy of a crown of gold, or a monumental record on the spot where the discovery was first made." But he adds elsewhere, with some bitterness of heart, "whilst the exploits of the conqueror and the intrigues of the selfish demagogue are faithfully preserved through a succession of ages, the persevering and unobtrusive efforts of genius, developing the best blessings of the Deity to man, are often consigned to oblivion!"

David Mushet, in addition to many papers in the *Philosophical Journal*, contributed largely to other scientific works. He wrote the article "Iron" for Macvey Napier's supplement to the Edinburgh edition of the *Encyclopædia Britannica*, and the articles "Blast Furnace" and "Blowing Machine" for Rees' *Cyclopædia*, both of which were frequently quoted in Parliament when, in 1807, it was proposed to levy a tax on iron.

Mushet discovered a mode for the preparation of bar-iron by a direct process, combining iron with carbon; he discovered also the beneficial effects of oxide of manganese on iron and steel; the uses of oxide of iron in the puddling-furnace in various modes of appliance; the application of the hot-blast to anthracite coal in iron-smelting, and the production of pig-iron from the blast-furnace suitable for puddling without the intervention of the refinery.

In 1800 he patented his process for combining iron with carbon for the production of steel; and afterwards, when he discovered the beneficial effects of oxide of manganese on steel, "Mr. Josiah Heath founded upon it his celebrated patent for making cast steel, which had the effect of raising the annual production of that metal in Sheffield alone from 3,000 to 100,000 tons. His application of the hot-blast to anthracite coal, after a process invented by him and adopted by the Messrs. Hill, of the Plymouth Iron Works, South Wales, had the effect of producing savings equal to £20,000 a year at those works; and yet," says Smiles, "strange to say, Mr. Mushet himself never received any consideration for his invention."

While David Mushet lived he was a leading authority on all matters connected with steel and iron, and he closed a laborious and useful life in 1847, at the age of seventy-five years.

PRINCIPLES OF DESIGN.—XXIX.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

HARDWARE (*continued*).

In ironwork the manifestation of a true constructive principle is beyond all things desirable. Iron, being a strong material, should not be formed into heavy masses unless immense weight has to be sustained or very great strength is required. If we form lamps, candelabra, and such works of iron, it is obvious that the portions of metal employed in their construction may be thin, as the material is of great strength. Were we to form such works of wood, then a greatly increased thickness of material would be necessary, in order that the same strength be secured, as wood is not nearly so strong as iron.

My remarks will have special reference to wrought iron, as cast iron cannot so fully be said to have a constructive character. A small railing (Fig. 133), which we engraved in our last article (page 217), is an admirable illustration of a true constructive formation, as the parts are all held together, and strengthened to a wonderful degree, by the introduction of a horseshoe-shaped member. This railing is worthy of the most careful study, for its strength is great. Besides strength we have also beauty. The horseshoe form, especially when judiciously applied, is far from being offensive. Utility must come

first, and then beauty, and so it does in this particular railing, but here we have great simplicity, and a correct structural character has been arrived at in its production rather than any elaboration of the principles of beauty.

From the catalogue of J. W. Dovey, of John Dalton Street, Manchester, I select an illustration of structure in the form of a candelabrum which is highly satisfactory in character as a simple work (Fig. 138). There is a solidly-formed heavy base, an upright stem terminating in a candle-holder. There is an arrangement for catching waste grease, and extra strength is given to the stem by four slender buttress-like brackets, which are securely and well attached to the base below and to the stem above; and these are strengthened by two hoops, which prevent their bending under pressure.

Figs. 139 and 140, the former being a ridge or wall cresting, and the latter a stair railing, are each illustrations of a correct treatment, inasmuch as strength (a structural quality) and beauty (an art quality) are secured at the same time. Fig. 139, it may be noticed, is admirably constructed, only it is a little slender above the middle horizontal line. These two illustrations are also from Mr. Dovey's excellent catalogue.

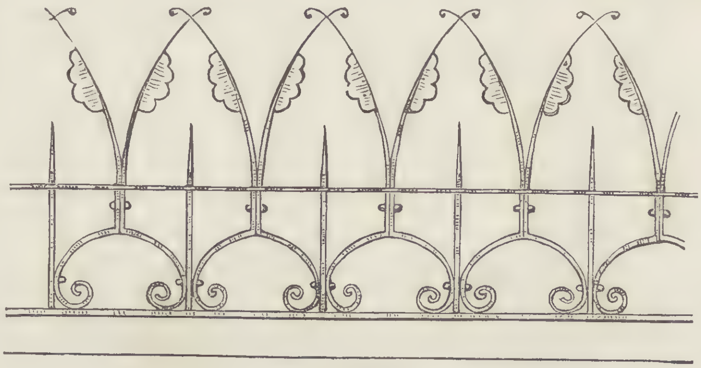


Fig. 139.

In the catalogue just named, and in those named in my last article also, many good examples may be found illustrative of the successful combination of true structural qualities with a considerable amount of beauty, and also acknowledging the strength of the material by the lightness of the parts.

Those who reside in or visit London, will do well to go to the South Kensington Museum, and study a large and splendid candelabrum of Messrs. Hart, Son, and Peard, which is well worthy of consideration. It is rather heavy, and is of enormous strength,

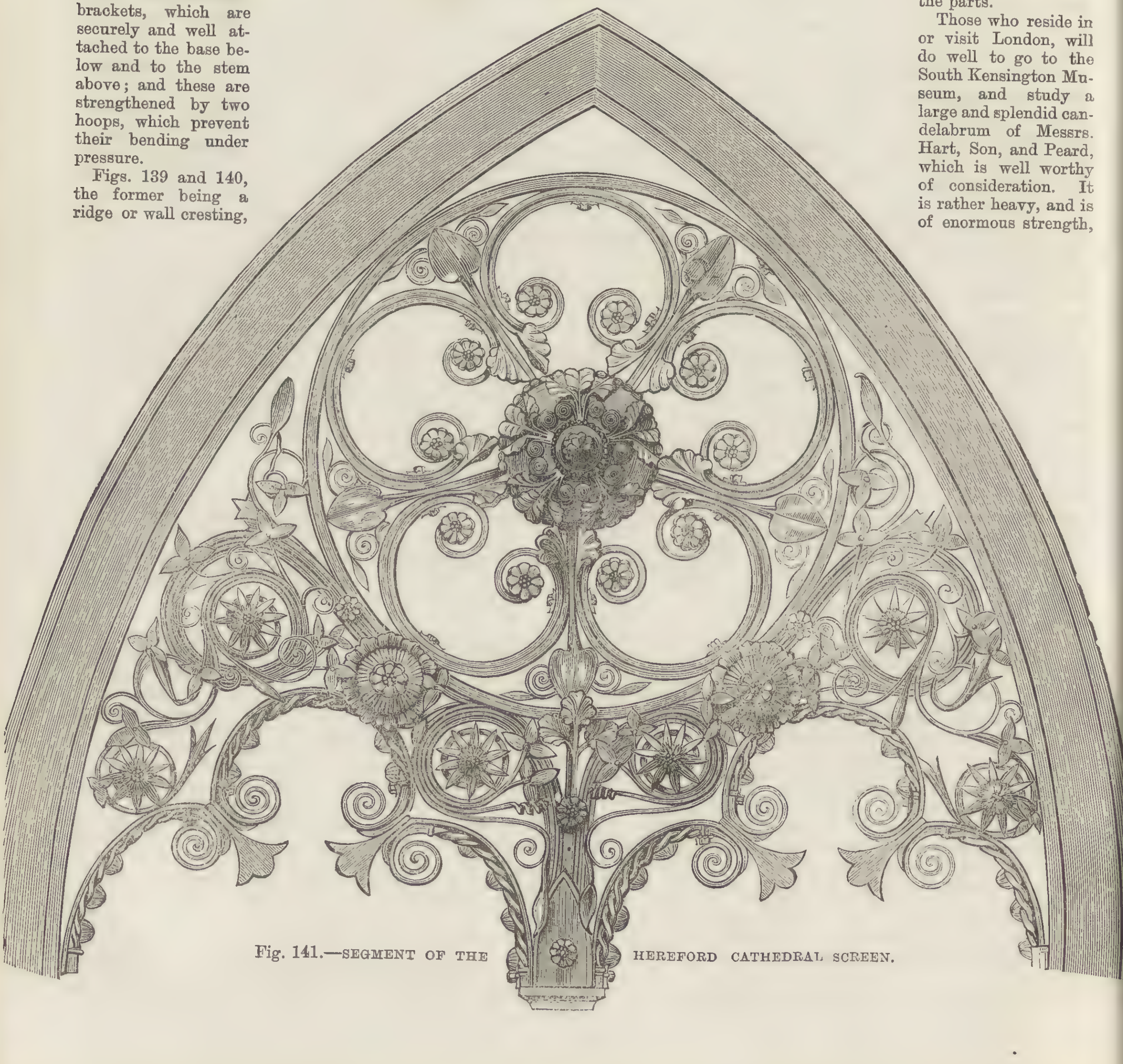


Fig. 141.—SEGMENT OF THE HEREFORD CATHEDRAL SCREEN.

but in most other respects it is highly commendable. It is beautiful, well proportioned, and illustrative of a correct treatment of metal. Besides this, it exemplifies the manner in which stones or jewels may be applied to works in hardware with advantage. As a further illustration of a correct and very beautiful treatment of metal we give one segment of the Hereford Cathedral Screen (Fig. 141), the work of that most intelligent of metal-workers, Mr. Skidmore of Coventry. This screen was shown in the International Exhibition of 1862, in London, and was from there removed to its place in the cathedral. All who can will do well to view this beautiful work, which is one of the finest examples of artistic metal-work with which we are acquainted. Notice the ease with which iron may be treated if a correct mode of working be employed. Let a bar of iron be taken which is about half an inch thick, by 1¼ broad. This can be rolled into a volute (the filigree mode of treatment), or its end can be hammered out into stems and leaves, and to it can be attached other leaves by rivets, screws, or ties, or it can be bent into any structural form. To the student I say, study the shapes into which simple bars of iron can be beaten, both mentally, and by observing well-formed works.

Brass, copper, and other metals may be associated with iron in the formation of any works. If well managed, brass and other bright metals may act as gems—that is, they may give bright spots; but where the bright metals are used with this view, care must be exercised in order that the bright spots be formed by beautiful parts, and that their distribution be just, for that which is bright will attract first attention.

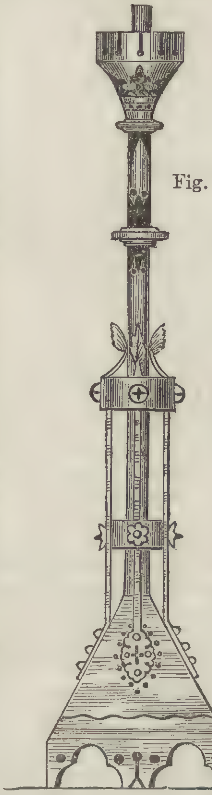


Fig. 138.

Fig. 140.

Before leaving this part of our subject, I must call attention to a hinge by Hardman, of Birmingham, which was shown in the International Exhibition of 1862, as it is both quaint and beautiful (Fig. 142). The door to which this hinge was applied opened twice; the first half opened and folded back on the second half, and then the two halves opened as one door, as will be seen from our illustration. It is very desirable that we have a little novelty of arrangement in our works. We are too apt to repeat ourselves, hence it is a sort of relief to meet with a new idea.

It is impossible that I take up each article of hardware and consider it separately. All I can do is to point out principles, and leave the learner to consider and apply them for himself—a principle which, once understood, may result in the construction of many excellent works, and may lead to the formation of a correct judgment respecting such objects as may be brought forward for criticism. I will, however, just call attention to gas-branches, as they are often wrongly constructed. A gas-branch is a duct through which gas is to be conveyed. It must be strong if it is to be exposed to pressure, or if it runs the chance of coming in collision with the person, as do standard lights in public buildings. The main part of a gas-branch is the tube or pipe which is to convey the gas, but this may be supported in many ways, as by such buttress-like brackets as in the candelabrum shown in Fig. 138; and if there are branch tubes for several lights, these may well be connected with the central tube, not only by their own attachment, but by brackets of some sort, or with one another by some connecting parts. Whether the gas-branch be pendent or standard, this mode of strengthen-

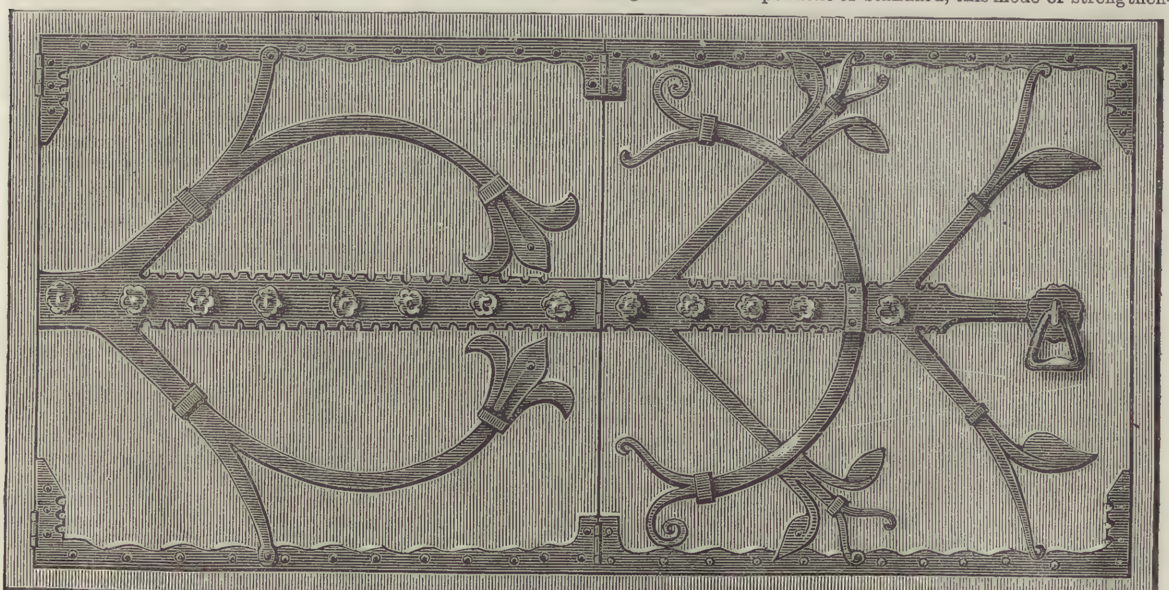


Fig. 142.

ing the tube-work should be employed, for the tubes themselves are but slightly held together, and by pressure being brought to bear upon them, a dangerous and expensive escape of gas may result.

In the manufacture of gaseliers one or two Birmingham houses have certainly distinguished themselves by the production of works both beautiful and true; and these lead me to think that a better day is dawning for Birmingham, in which its art shall be exalted rather than degraded, and shall be such as will win to it the esteem of the world rather than call forth the execrations of art-loving people.

As to the colouring of iron I can say little. In my judgment the best modes of colouring metals were originated by Mr. Skidmore of Coventry, of whom I have before spoken. His theory is this, that metals are best coloured by the tints of their oxides. When a metal, especially brass, is seen in a furnace in a molten condition, the flames, where the oxygen of the atmosphere is uniting with the vapour of the metal, present the most resplendent tints. The same thing in a lesser degree occurs in the case of iron, but here the colours are less brilliant, and are more tertiary in character. Mr. Skidmore applies to a metal the colours seen in the flames of the furnace where it melts. Without attempting to limit the colourist to any theory whereby his ideas might be restricted, I must say that Skidmore's colouring of the metals is very good.

SEATS OF INDUSTRY.—XXV.

NEWCASTLE-UPON-TYNE.

BY WILLIAM WATT WEBSTER.

The importance of coal as an agent in modern domestic, manufacturing, and commercial economy can hardly be exaggerated, and no country in the world has reaped so much benefit from its possession and use as Great Britain. It is to the richness of our coal-fields, and to the industry and skill with which they have been worked, that we owe in a great measure our manufacturing and commercial prominence among the nations. "We are living," as Robert Stephenson once said, "in an age when the pent-up rays of that sun which shone upon the great carboniferous forests of past ages are being liberated to set in motion our mills and factories, to carry us with great rapidity over the earth's surface, and to propel our fleets, regardless of wind and tide, with unerring regularity over the ocean." It is calculated that about 70,000,000 tons of coal are now annually raised in the United Kingdom, and the coal-mines of Durham and Northumberland produce about one-third of this total. Newcastle-upon-Tyne is the capital of Northumberland, and the port from which the coal excavated in that county, and in the neighbouring county of Durham, is exported to other parts of Great Britain and to foreign countries. It is the principal centre of the coal-trade in England, and to a great extent it is indebted for its prosperity to the convenience of its situation as a port of shipment for the coal found in the neighbouring districts.

The history of Newcastle stretches back to the time of the Roman occupation. It was one of the stations on the wall erected by the order of the Emperor Adrian, A.D. 120, to defend the Roman provinces from the incursions of the Caledonians, and which traversed the island from the Solway Firth to the Tyne, terminating at Wallsend, about three miles to the east of Newcastle. The place was named Pons Ælii by the Romans, from a bridge built over the river by the same emperor, and called by his family name. Round this bridge the first nucleus of Newcastle was formed. About the year 208 A.D., the Roman wall originally constructed by Adrian was rebuilt by Septimius Severus, after a repulse he suffered from the Caledonians. From the fact that cinders are frequently found among the remains of Roman stations in Northumberland, it would seem that the use of coal was not unknown to the Romans, although the abundance of timber probably restricted its use to neighbourhoods where it was obtained at or near the surface. After the departure of the Romans from the island, the Anglo-Saxons expelled the Britons from this part of the country, and founded the kingdom of Bernicia. In the immediate vicinity of Pons Ælii the Saxon kings had an occasional residence, called *Ad Muram*, and after the conversion of the Saxons to Christianity the deserted Roman camp was occupied by a colony of monks, from whom it derived the name *Moncaster*, or *Monkchester*. At that period it was the resort of numerous pilgrims, who came to the holy well of Jesus Mount, now Jesmond, about one mile to the north-east. Owing to the incursions of the Danes, the monks were compelled to abandon the place, and it fell into the possession of the Scots.

No satisfactory evidence that coal was either an article of commerce or of domestic use during the Saxon period has been discovered. Shortly after the conquest of England by William of Normandy, the Scots were driven from their settlement on the Tyne by Robert, the eldest son of the Conqueror, who in 1080, during the lifetime of his father, hastily built a castle there on his return from a hostile excursion into Scotland. At that time the town received the designation it now bears. This castle was rebuilt by William Rufus, who also surrounded the town with walls, and conferred peculiar privileges on its inhabitants. The benefits conferred on the town by William II. are commemorated in the following rude lines in Hardynge's "Chronicle:"—

> "He builded the New Castle upon Tyne,
> The Scottis to gainstand: and to defend
> And dwell therein the people to incline,
> The town to build and wall, as did append,
> He gave them ground, and gold full great to spend,
> To build it well and wall it all about;
> And franchised them to pay a free-rent out."

The present castle, however, which is the best example of Norman military architecture in England, was erected by Henry II., between the years 1172 and 1177. A charter is said to have been granted to the town by King John, but the earliest charter extant is that of Henry III., dated 1234, in which, "upon their supplication," the inhabitants are granted the privilege "to dig coals and stones in the common soil without the walls, and to convert them to their own profit, in aid of their free-farm rate of £100 per annum." In the reign of Edward I. Newcastle was captured and burned by the Scots, it having been used by that monarch, and by his successors Edward II. and Edward III., as a rendezvous for the great armies with which they attempted to conquer Scotland. Portions of the walls constructed after this disaster still remain. During the reign of the last-mentioned king, Newcastle successfully resisted an attack made on it by the Scots under David Bruce, and in 1299 the walls on the eastern side were rebuilt. At this early period Newcastle was one of the most important commercial ports in the kingdom, and was noted as a nursery for seamen, and as a resort for merchants and tradesmen of all classes.

The introduction of sea-coal as household fuel encountered an intense and prolonged opposition. It was believed that the smoke from coal was injurious to health, and so strong was this prejudice, that in the reign of the first Edward a man was hanged for having burned it within the walls of London. In accordance with a petition presented to Parliament, the king issued a proclamation, in 1316, prohibiting its use in the metropolis, and as this did not prove effectual, recourse was had to severer measures. Fines were imposed on a first conviction for burning coal, and the penalty for a second offence involved the destruction of the furnaces, etc. But coal would seem to have made gradual progress in spite of all that could be done to suppress its use. In his "Agriculture and Prices in England," Mr. Roger says:—"The appearance at so distant a place as Dover, in 1279, the earliest entry that has come under my observation, suggests that the coasting traffic in this article must have been familiar. It was purchased for the use of the castle, and must, of course, have been burned in a fireplace with chimney. It may be added that among the various traders given in the taxing-bill of Colchester, 'Rot. Parl.,' vol. i., sea-coal dealers are mentioned at the close of the thirteenth century." In 1280 Newcastle had a considerable trade in coal, and soon afterwards it was introduced into London, although at first it was burned only by smiths, brewers, soap-boilers, dyers, etc. The exportation of coal from Newcastle to foreign countries is believed to have commenced about the year 1325. In 1346 the port supplied, on the requisition of Edward III., 17 ships and 314 mariners for the siege of Calais, a larger force than was furnished by any port north of the Thames,

Yarmouth alone excepted. Eleven years later this monarch granted to the inhabitants of Newcastle the entire possession of the Castle Moor and the Castle Field adjoining, "for the purposes of there digging of coals, stone, and slate." Towards the close of the fourteenth, and during the earlier years of the fifteenth centuries, there flourished in Newcastle one of the most eminent merchants of his time, Roger Thornton, "the richest merchant that ever was dwelling in Newcastle," who was three times mayor, and three times member of Parliament, and did much to develop the trade and further the interests of the town. It prospered and increased steadily all through the fifteenth century, and under the Tudors in the sixteenth century the chief trade of the town consisted in the exportation to the Continent of "canvas, sheepskins, lambsfelts, lead, grindstones, coals, and rough-tanned leather." The manufacture of glass was first introduced into England in the reign of Queen Elizabeth, by a body of immigrants from Germany, who established themselves in the neighbourhood of Newcastle.

In the reign of Charles I. Newcastle suffered two severe afflictions. It was visited by the plague in 1636, which carried off 5,000 of the inhabitants; and in 1640 it was surprised and captured by the Scottish army under General Leslie. During this king's reign the use of coal became universal in London. Newcastle espoused the cause of Charles I. against the Commonwealth, and was garrisoned by the Royalists during the Civil War; but at a late period it again fell, after a prolonged siege, into the hands of the Scotch, then in alliance with the Parliament. The author of "Chorographia; or, a Survey of Newcastle-upon-Tyne," writing in the time of the Commonwealth, says:—"Many thousands are engaged in this trade of coals; many live by working of them in pits, and many live by conveying them in wagons and wains to the river Tyne." Some idea of the magnitude of the Newcastle coal-trade at the beginning of the eighteenth century may be formed from the report made by the Master of the Newcastle Trinity House to Parliament, which states that 600 ships, each carrying 80 Newcastle chaldrons of coal, and navigated by a total of 4,500 men and boys, were required for the supply of other ports with that article.

The progress of the coal-trade, and with it the prosperity of Newcastle, were for a long period impeded by the creation of monopolies, and the imposition of oppressive regulations and exactions. From a very early period the Corporation of London had undertaken the task of weighing and measuring the coal brought to the metropolis, and had charged eightpence per ton for their trouble. The power to make this charge was confirmed to the City by charter in 1613. In the reign of Charles I., two monopolies, still more directly affecting the interests of Newcastle, were granted. Sir Thomas Temple and his partners were, in 1637, assigned the exclusive right of selling all the coal exported from Newcastle for twenty years from that date; and in the following year a company of monopolists was empowered to buy all the coal produce of Newcastle, Sunderland, and Berwick, and to sell it in London for any price not exceeding the very high rate of seventeen shillings per chaldron in summer, and nineteen shillings in winter, one shilling per chaldron being the king's share of the profits. These monopolies, along with hundreds of others equally grievous, were abolished by the Long Parliament. Duties for City improvements and other civil purposes have, however, been charged upon coal imported into London from the time of Charles II. to our own day. These rates were first imposed after the Great Fire of 1666, to assist in the rebuilding of the churches and public edifices that had been destroyed. The duties of all descriptions that had been previously laid upon coal brought into London were commuted in 1836 for a rate of 1s. 1d. per ton, which in 1851 produced a gross revenue to the City of £187,991. Eightpence per ton of this rate would have lapsed in 1862 but for the Act of 1861, which continued it in its entirety till 1872, and for the Acts 26 and 27 Vict., c. 46, by which a duty to the extent of one shilling was further continued to 1882, two-thirds being mortgaged for the Thames Embankment and one-third for the Holborn Viaduct; and 31 Vict., c. 17, which again further extended the time of its imposition to 1889, a third of the rate being under this Act applied to the freeing of certain suburban bridges and tolls. An idea of the importance and growth of the London coal-trade may be gathered from the following statistics:—At the Restoration it is calculated that about 200,000 chaldrons were annually imported into the metropolis, and in 1670 the quantity amounted to 270,000 chaldrons. At the Revolution 300,000 chaldrons were brought to London, and in 1750 the quantity was about 500,000 chaldrons, and fifty years later 900,000. In 1866 there was brought into London by sea, rail, canal, and road, no less than 6,020,182 tons of coal, yielding in duty £270,000. The quantity of coal exported from Newcastle in 1801 was 452,092 chaldrons sent coastwise, and 50,401 over sea; in 1811, 634,371 sent coastwise, and 18,054 over sea; in 1821, 692,321 sent coastwise, and 48,097 over sea; and in 1832 the number of chaldrons shipped amounted to 748,348. It must be stated that the Newcastle chaldron, by which the above quantities are estimated, is nearly equal to two chaldrons London measure. The aggregate capital employed by the coal-owners on the Tyne at the present time amounts to about £4,500,000, exclusive of the craft on the river, and the total capital employed in the coal-trade may be moderately estimated at from twenty to twenty-five millions sterling. It is calculated that upwards of 60,000 persons are directly employed in the coal-fields connected with Newcastle.

The export of lead from Newcastle, taken from the mines of Northumberland and Durham, is of great antiquity, and in the earliest records that have been preserved these mines are described as silver mines. Large quantities of lead are annually brought from the Alston Moor and Wearland mines to Newcastle for shipment, and for manufacture into sheets, shot, and red and white lead, and silver is to some extent extracted from the lead ore. Only a small quantity of iron ore was smelted on the Tyne previous to the discovery of the Cleveland ironstone, but since that time this industry has increased enormously, and about 60,000 tons of iron and 3,000 tons of steel are now annually produced there. Copper to the value of about £100,000 is also annually obtained from the copper pyrites used at the great chemical works on the Tyne. The quantity of coke yearly manufactured amounts to some 2,500,000 tons. The locomotive and engineering establishments in Newcastle and the vicinity are among the largest and the most celebrated in the kingdom, Sir William Armstrong's ordnance works at Elswick, a western suburb, being perhaps the most famous. During the past year the operative engineers of this town succeeded, after a long and determined strike, in obtaining a reduction of the hours of labour to nine hours per diem—an event that is likely to exercise a powerful and beneficial influence on the condition of the working classes generally throughout the country. Iron ship-building is carried on, as well as the building of wooden and composite vessels, upon an extensive scale on the Tyne, iron vessels reaching an aggregate of 51,236 tons having been launched in 1863. The chemical manufactures of Newcastle and the neighbourhood have grown to extraordinary dimensions since 1816. It is calculated that upwards of 100,000 tons of salt are annually decomposed in the district, for the production of crystals of soda and other mineral alkalis, while bleaching powder, vitriol, copperas, coal pitch, spirits of tar, aquafortis, glue, vinegar, soap, etc., are manufactured in large quantities. The production of window and flint glass has considerably declined during the last few years, but enormous quantities of bottles are still made at Newcastle and in its immediate neighbourhood, while impressed glass is largely made, and plate-glass to a certain extent. Earthenware also forms an important branch of industry in the town, and glass-staining has been carried to a high degree of perfection.

FARMING AND FARMING ECONOMY.—XIII.

By Professor Wrightson, Royal Agricultural College, Cirencester.

CATTLE.

INTRODUCTORY—PLACE IN ANIMAL KINGDOM—ORIGIN OF EUROPEAN CATTLE.

A correct and intelligent knowledge of the British races of cattle can scarcely be attained without some insight into the position which they occupy in the animal kingdom, and their relations to allied domestic cattle found in other parts of the world. The study of the origin and development of a race of domesticated animals has many elements of interest. Sprung from a wild stock at a remote period of time, they

have lost many of their natural instincts and characters, and assumed a form which can only be preserved under highly artificial conditions. They have been moulded by art, and adapted to the requirements of man, until it is difficult to realise what the form and character of the wild progenitor really was. Our cattle only exist in the domesticated condition, and although feral or escaped cattle abound as wild animals in many parts of the world, true native and perfectly wild cattle do not occur.

It is true that in Chillingham and other parks "wild cattle" are preserved, probably the direct descendants of an aboriginal forest breed. These have, however, been for many generations confined within narrow bounds, and exposed to more or less unnatural and modifying conditions. "The (Chillingham) cattle," writes Darwin, "in their instincts and habits are truly wild. They are white, with the inside of the ears reddish-brown, eyes rimmed with black, muzzles brown, hoofs black, and horns white, tipped with black." At Chartley, the seat of Earl Ferrers, a similar breed exists, and there black calves are occasionally dropped. These cattle represent *Bos primigenius*, well known as a formidable wild animal in Cæsar's time, now semi-wild, and much degenerated in size. We propose to return to this interesting subject, but in the meantime it will be well to glance at the general position of the large family of oxen (Bovidæ) in the animal kingdom, and in doing so we shall also detect the links connecting sheep with cattle in a distinct relationship.

The Bovidæ, or Oxen, are a family of the Ruminantia, a remarkably well-defined, natural order of the herbivorous Mammalia. The general characteristics of this order may be stated as follows:—All are exclusively herbivorous, and, with the exception of camels and llamas, are destitute of incisor teeth in the upper jaw; the toes, two in number, are enveloped in distinct hoofs, and many of the species have two supplementary hoofs in addition; all chew the cud, and are furnished with three or four stomachs. With the exception of the camels and musk deer, all are horned.

The order is divided into families as follows, according to the nature of the horn. (1.) The Camels and Musk Deer, without horns. (2.) The Cervidæ, or Deer, with deciduous horns. (3.) The Giraffe, constituting the family of Camelopardidæ, and characterised by possessing two frontal horns in both sexes, conical and truncated, short, covered with hairy skin, and persistent (Van der Hoeven). (4.) The Antelopes, or Antelopidæ, the first of the hollow-horned ruminants (Cavicornia of Van der Hoeven), distinguished by the persistence of their horns, which are composed of a hollow or bony core covered with a horny sheath. This family is further divided into true Antelopes, remarkable for their grace and lightness of form and agility; the Bush Antelopes, with shorter limbs and more compact form; the Capriform, or goat-like antelopes, represented in Europe by the Chamois goat; the Boviform, or ox-like antelopes, which present various degrees of likeness to oxen. (5.) The Bovidæ, or Oxen, distinguished from all the antelopes by their bulky form and great strength. It is also interesting to note at this point the position of sheep and goats, the Capridæ, which are, like oxen, connected with the antelopes by an intermediate sub-family, the Capriform Antelopes.

The Bovidæ, or Oxen, are thus described by Martin:—"In both sexes the head is armed with horns (we of course except the polled domestic breeds of cattle), and these horns consist of an external layer of corneous fibres, compacted together, and sheathing a cancellous, bony core, continued laterally from a bold occipito-frontal ridge. . . . The progressive increase of the horns is marked by successive ridges or rings at the base. . . . Their form is heavy and massive, their stature generally large; the limbs are low and strong; the haunches wide; the shoulders thick; the head large; the forehead or chaffron expanded; the muzzle (rhinarium), with certain exceptions, broad, naked, and moist; the tongue rough, with hard horny papillæ directed backwards; the neck thick, deep, compressed laterally, carried horizontally, and furnished with a pendant dewlap; the spinous processes of the anterior dorsal vertebræ (withers) are very long and stout." All the ox tribe are gregarious in their habits, and, with the exception of Australia, occur in every quarter of the globe.

This family has been divided as follows into four groups:—Cattle and Buffaloes, having thirteen pairs of ribs. Bisons and the Yak, having fourteen pairs of ribs. Besides these there is also the Musk Ox, or Ovibos (*Bos moschatus*), an animal which constitutes the genus Ovibos of Blainville and Desmar. This animal has a hairy muzzle, and short tail concealed under long hair; the horns approach each other at the base and then proceed outwards and downwards, the points turning up again nearly as in the gnu (Van der Hoeven).

In MM. Moll and Gayot's excellent work on cattle the points of difference between these groups is ably discussed. Taking them in the above order, cattle are distinguished by horny papillæ upon the tongue, by circular rings at the bases of the horns, and by the teats being arranged in the form of a square. This group includes—(1.) The common ox (*Bos taurus domesticus*) and the variety already mentioned; park or forest cattle (*B. sylvestris*) found in Britain in a semi-wild condition as above; the Zebu, or humped cattle of India (*B. Indicus*); and the white buttocked cattle (*Bœuf à fesses blanches*), (*B. bentiger*) which occupy Java and Borneo in a wild state. (2.) The Gour (*B. gaurus*) and the Gayal (*B. gavæus*), both remarkable for the development of the bony spinal processes which give rise to the withers.

The Buffalo (*B. bubalus*) is distinguished by a smooth tongue, horns triangular at the base, and teats set in the form of a trapezium. The buffalo is indigenous to Asia, and is found over a wide area. He has been largely used as an animal of draught; is completely black in hair, skin, hoofs, and horns; possesses short, thick limbs, and a massive body; forehead arched; muzzle large; horns directed outwards and backwards, and finally turning upwards towards the point; hair scattered thinly over the body, but forming tufts on the forehead, knees, and fetlocks; the dewlap is but little developed. He is useful as an animal of draught, especially in humid and fenny countries, where ordinary cattle would not thrive; as, for instance, in the Pontine Marshes. The flesh is inferior to ox-beef, and is sold at a low price in Italy. The milk is excellent. He is very fond of bathing, a partiality which is often inconvenient, as he has been known on sighting a river to rush towards it, laden with perishable goods, and plunge into its midst, there to enjoy the delights of the bath, and to sleep for hours, totally immersed with the exception of his nose.

The Bonassus, or Bison. This group comprises the European bison or auroch, and the American bison, sometimes called buffalo. The auroch is the only member of the ox tribe found wild in Europe. He is, however, exceedingly rare, and is only found in the forests of Moldavia, and in the governments of Grodno and the Caucasus, in the Russian Empire.

The bison differs from the auroch in having fifteen pairs of ribs. In other respects both the European and American species resemble each other. Both are disproportionately larger in the anterior than the posterior portions of the body, due to the great development of the spinal processes of the dorsal vertebræ, which support large masses of flesh (the bison hump) on either side. This ungainliness of form is further exaggerated by a thick coating of hair on the neck and shoulders, which is composed of two qualities. The first, long, coarse, stiff, and harsh to the touch; and underneath this a soft, fine wool, reputed finer than that of the merino sheep. The colour of the bison is blackish brown, turning in the adult male to almost black. These powerful animals have, according to M. Rafinesque, been employed in agricultural work, especially in Kentucky, and the same authority states that they cross freely with ordinary cattle, and that the hybrids are fertile among themselves, and with the two parent species.

The yak has only recently appeared in Europe. He in some respects resembles the zebu. The hump, however, of the zebu consists of fat, while the elevation of the withers in the yak is due to the elongation of the vertebral spines previously mentioned. The yak has a very short neck; horns rising vertically from his head; limbs short, light, and terminated by small hoofs. In general outline the yak more nearly approaches the horse than the ox, and he is well adapted both to draw and carry weights. He is covered with a long fleece, which, like that of the bison, is divided into two portions: an under-growth of exceedingly firm wool, which in Thibet is mixed with the soft hair of the Cashmere goat, in the fabrication of those valuable tissues for which the country is famed. The yak is invaluable in North China, Thibet, and the slopes of the Himalayan Mountains, where he figures as an animal of draught and of burden, a source of milk, of flesh, and of wool. The Imperial Acclimatisation Society introduced this useful

animal into the Jardin des Plantes, at Paris, in the hope that he might become useful in mountainous districts in Europe.

Having considered with, we hope, sufficient brevity the various members of the Bovidæ domesticated by man, we must now devote ourselves to the study of common cattle (*B. taurus domesticus*). Professor Lowe enumerates nineteen breeds of British cattle. Desmarest describes fifteen French races, excluding sub-varieties and imported breeds, and MM. Moll and Gayot figure fifty-five European varieties in their "La Connaissance General du Bœuf." The origin of these closely allied, yet evidently well marked, tribes has been traced by Nillson and Rütimeyer. Following the latter authority, we may mention *Bos primigenius*, the ancestor of some of the larger Continental races, as the Friesland and Hungarian cattle, the Pembroke in Britain, and which, no doubt, now exists in a degenerate form as the wild or semi-wild ox of Chillingham Park. Besides *Bos primigenius*, there are two other extinct species of the genus, from which our European cattle are supposed to have been descended. The first of these, *B. longifrons* or *brachyceros*, was of small size and short-legged. The Highland and some of the Welsh breeds are supposed by Professor Owen to have been descended from this species. Remains of *Bos longifrons* have been found associated with those of the elephant and rhinoceros. The last species, *B. frontosus*, existed in the same late geological period, and is believed by Nillson to have been the progenitor of the mountain cattle of Norway. This species is distinguished by a bony protuberance on the skull, between the horns. We see, therefore, that at least three distinct species of ox have been domesticated in Europe. The uniform colour of the Chillingham cattle has always been one of their best marked peculiarities. In general, the colour may be described as white, with reddish-brown inside the ears. This uniformity of colour is to be observed in several domesticated foreign breeds, and it has been ascertained that cattle which have run wild in the Ladrone and Falkland Islands have assumed a similar light or white colour, with black ears and occasionally black heads. Numerous instances might be given to show the tendency of escaped cattle to become white, with coloured ears, while in other cases a uniform dark brownish-red hue has been assumed. This general tendency has been considered to indicate the colour of at least one of the original wild prototypes of our cattle.

GREAT MANUFACTURES OF LITTLE THINGS.—VIII.

LOCKS *(continued from Page 229)*.

BY CHARLES HIBBS.

THE great convenience of the warded lock for ordinary purposes induced many attempts to provide it with additional features of security. We shall not pretend to notice these in chronological order, our object not being to write a history of the lock manufacture, but rather to illustrate the growth of correct principles in construction. Among other meritorious inventions, one was patented by a Wolverhampton maker, which effectually prevented the possibility of opening the lock with a skeleton key, or making a false key by taking an impression of the wards. The bitt of the key was made telescopic, and would only enter the key-hole when pushed up to its shortest length, while it would only act upon the bolt when drawn out to its longest. In the first part of its revolution it passed over a ward which gradually thickened, and so, by widening the slot, elongated the bitt sufficiently to reach the bolt, after which a fixed piece of metal, so placed that the end of the bitt rubbed against it in its rotation, acted upon it like an inclined plane, and pushed it back into its former shape.

But the inherent defects of the system were incurable. The most obvious was that the obstacles to surreptitious unlocking lay all in the small compass that was represented by the size of the bitt of the key. However ingeniously the position of the wards might be varied, or even their functions changed, as in the last example, it was not possible to produce more than a limited quantity of locks of any given size, the keys of which should materially differ from each other. The maker would soon exhaust all the variations capable of being put into so small a space, and would therefore be compelled to reproduce some, or all of them, to an indefinite extent. This was, of course, more especially the case with regard to the commoner sorts, of which perhaps tens of thousands might be made with their ward arrangements all alike. What security could be felt by the owner of a lock, however complex, if he knew that there must necessarily be others exactly like it in existence somewhere, and that any bunch of keys might happen to contain one that would unlock it? There was another radical defect in the principle, inasmuch as the *impedimenta* all lay in the way of the passage of the *key*, and there was nothing, except the downward pressure of the back spring, to hinder the passage of the bolt. Any one who could gain access to the end of the bolt could shoot it back with a moderate push. In these two essential parts of the principle lurked a fatal element of insecurity; nor was it overcome until the adoption of the tumbler system, which marked a new era in lock-making.

In this system, while the exterior shape of the lock and key was unaltered, and the action of the bitt upon the talon of the bolt remained precisely the same, the wards, the back spring, and the notches on the under side of the bolt, were all taken away. In place of them two square notches were cut on the upper side, and a tumbler, or latch, furnished with a stud that fitted them easily, was hinged at one end immediately over the bolt. This latch was of sheet metal, wide enough to hang like a curtain in front of the bolt, covering about half its surface, the stud being fastened at right angles to its upper edge. When the bolt was *half* shot, this stud was resting upon its top surface, being pressed thereon by a light spring, but when in the locking or unlocking position, the stud fell into one or other of the notches. The bolt was therefore held firmly in its place until the tumbler could be lifted and the obstruction cleared. This was effected by the bitt of the key being stepped to correspond with the depth of the overhanging tumbler, so that when it was turned round to reach the talon of the bolt, it at the same time raised the tumbler to a height sufficient to free the stud from the notch. This simple application of the principle, which we have described first for the sake of clearness, would not of itself afford much security, it being easy to contrive a false key which should effect the required movement; but the difficulty was greatly enhanced by having two or more tumblers, each hinged on a common pivot, but working with its separate stud into a separate pair of notches. The depths were also varied, so that the under edges of the tumblers, technically called their "bellies," hung at different heights, and required corresponding steps to be cut upon the bitt of the key. So far a great advance was made, but still the plan was seriously defective. The tumblers might be lifted to *any* height, and a false key need not be made with such extreme nicety as just to lift the studs out of the notches, and no more, but might be stepped at a rude guess, and, so that it lifted the tumblers high enough, would effect its object equally with the true key. To meet this, an ingenious arrangement was devised. The studs of the tumblers no longer rested on the top of the bolt, but lay in a slot cut out of its middle part, the notches being cut downwards from the slot. Had such been the whole of the arrangement, the studs could not have been lifted higher than the upper wall of the slot. But here a new element was introduced. Corresponding notches were cut *upwards*, opposite to the lower ones, so that if the tumbler were overlifted, the stud entered the upper notch, and equally prevented the passage of the bolt. The slot in the bolt thus resembled rudely the letter H, the upper and lower notches being sufficiently wide to receive the several studs lying side by side. This was a great improvement. If the workmanship were moderately accurate, no false key that was not an exact duplicate of the true one could possibly open the lock. If its steps were too low, they would not lift the studs out of the lower notches, while, if they were too high, they would certainly elevate the studs into the upper notches, and leave the bolt as fast as ever.

Although this lock was not susceptible of being picked, as the warded lock was, by a skeleton key, it was still not altogether proof against the nefarious attempts to make a false key by means of an impression taken of the interior. The bellies of the tumblers hung, as we have explained, at irregular depths, and any means by which an accurate measurement could be taken of their position would indicate exactly the number and depth of the steps to be made upon the key. A blank key, smoked, would show which of the tumblers was first touched, and this at once indicated the place where the lowest

step was to be filed away; and by repeating this process until, by patient trial and filing, the shape of the false key became the exact converse of the lower edge of the hanging row of tumblers, a perfect duplicate of the true key might be made. This fraudulent expedient, too, might be materially facilitated by catching a sight of the tumblers in position through the keyhole, by means of a small mirror, thus enabling the operator to get on with his work to a certain extent before he began to take his smoked impressions, which would be only needed for the finishing strokes. It was speedily felt to be a desideratum that the bellies of the tumblers should lie all upon a plane, so as to afford no indication to the picker as to the height they required to be lifted. This was effectually done by the simple and beautiful expedient of placing the stud upon the bolt, and the slot, or gating, in the tumbler. It was not now the stud which fell into the notch, but the notch which fell upon the stud. The gating—that being the technical term—bore still the rude semblance of the letter H, but according as the legs of the letter were made longer or shorter, the tumbler fell through a greater or a lesser space. Only when the tumblers, or, as they were now sometimes called, the levers, were lifted simultaneously to the position in which the horizontal slots, or cross bars of the H, came together and formed one slot, could the stud, which projected through them all, pass from the locking to the unlocking position, or *vice versâ*. At either of those positions each of the levers fell through a different space, and of course required to be lifted accordingly by steps upon the key, although the bellies of the levers, when down, formed one unbroken surface. It will be clear that if either of the tumblers were overlifted, as would probably be the case with a false key, the lower notch would catch the stud with the same result as when the gating was in the bolt.

We must now proceed to explain the *rationale* of the immense additional security afforded by these locks, in respect of the almost infinite variety with which they can be produced; and we cannot do so better than in Mr. Chubb's own words, taken from his admirable essay. He says:—"The number of changes which may be effected on the keys of a three-inch drawer lock is $1 \times 2 \times 3 \times 4 \times 5 \times 6 = 720$, the number of combinations which may be made on the six steps of unequal lengths (on a six-tumbler lock) without altering the length of either step. The height of the shortest step is, however, capable of being reduced 20 times, and each time of being reduced the 720 combinations may be repeated; therefore, $720 \times 20 = 14{,}400$ changes. The same process, after reducing the shortest step as much as possible, may be gone through with each of the other five steps; therefore, $14{,}400 \times 6 = 86{,}400$, which is the number of changes that can be produced on the six steps. If, however, the seventh step, which throws the bolt, be taken into account, the reduction of it only ten times would give $86{,}400 \times 10 = 864{,}000$, as the number of changes on locks with the keys all of one size (that is, with one key of definite size in all save the lengths of the steps). Moreover, the drill-pins of the locks and the pipes of the keys may be easily made of three different sizes; and the number of changes will then be $864{,}000 \times 3 = 2{,}592{,}000$ as the whole series of changes which may be gone through with this key. In smaller keys, the steps of which are capable of being reduced only 10 times, and the bolt-step 10 times, the number of combinations that may be made will be $720 \times 10 \times 6 \times 5 \times 3 = 648{,}000$. On the other hand, in larger keys, the steps of which can be reduced 30 times, and the bolt-step 20 times, the total number of combinations will be $720 \times 30 \times 6 \times 20 \times 3 = 7{,}776{,}000$." Another lock-maker, Mr. Parsons, showed by a curious table that a lock with 26 levers would admit of 403,291,461,126,665,635,584,000,000 different combinations!

The reader will now see that the plain Chubb key, which has so very unpretending an appearance, as compared with one of the old-fashioned pattern, filled with mazy wards, is in reality a much greater emblem of safety. We must inform him that means are taken by all makers of repute to ensure that the permutating principle shall be carried out as a reality, and not as a sham. The difference between one lock and another is not a matter of haphazard. The keys are, as a rule, made first, and the tumblers adjusted to correspond, that being the method which is found in practice to work the best. The steps are cut by a machine, with which is connected a dividing plate, having notches in its circumference graduating in depth from the highest to the lowest of the steps that are capable of being cut on that particular sized key which the machine is constructed to operate upon. We have seen that even on a small key, not only may the relative positions of the steps be changed, but that each of them may be reduced in height twenty times; there may therefore be a great number of notches on the periphery of the dividing plate, and yet the depths of all will differ in some slight degree. On the surface of the plate, against each notch, a number is engraved, and the operator, working upon an infallible arithmetical system, is thus enabled, by reading off these numbers, to adjust the machine to a succession of combinations, none of which can be repeated until the whole series is exhausted. The notches, it will readily be apprehended, govern the action of the cutting tools, and regulate exactly the height of the steps that are being made upon the key.

These locks were long considered to be impregnable, but we have now to recount the history of their defeat by the invincible American. The first stroke at our fancied security was made by him at the Crystal Palace in 1851, when he declared to a party of scientific men that none of the locks made in this country were proof against a properly directed assault. To prove his statement, he picked one of Chubb's patent detector locks in their presence in a few minutes. Shortly afterwards he made a sort of public challenge to the Messrs. Chubb, by notifying them that he would attempt, on the following day, to pick one of their locks which was on the door of a strong room in the City, and inviting them to be present. They did not avail themselves of the invitation, and the trial came off in the presence of eleven gentlemen of unblemished honour and integrity, who certified that Mr. Hobbs fairly picked the lock in twenty-five minutes, and locked it again in seven minutes with the same instruments. The event was much commented upon in the public press, and thus began the great lock controversy, which we must not follow for want of space.

Mr. Hobbs's dictum was as follows: "Whenever the parts of a lock which come in contact with the key are affected by any pressure applied to the bolt, or to that portion of the lock by which the bolt is withdrawn, in such a manner as to indicate the points of resistance to the withdrawal of the bolt, such a lock can be picked." This indicates the method which has been called the tentative or mechanical method, to which we have already introduced the reader in the description contained in a former article of the manner of picking the letter lock. The principle consists simply in applying pressure to the bolt in the direction tending to unlock it (if it is locked), and then feeling the tumblers very gently, one by one, until the one is discovered which is being pressed most hardly by the stud. It is scarcely within the power of human skill to make the lock so nicely as that the stud shall press equally upon all, and consequently one will be found to be fast and the others loose. The bound tumbler being lifted up very gently, a slight, very slight *give* of the bolt will tell when the unlocking slot has come into position. One of the loose tumblers will now become tight, and must be treated in the same manner, and so on, until by turns all have been got into the required position, when the lock will come open. It need scarcely be said that this is a most delicate operation with a well-made lock, and that a suitable instrument has to be used. That with which Mr. Hobbs worked was simple and ingenious. The reader understands that the only part of the bitt which acts upon the bolt is its final and longest step, the office of the other steps being merely to lift the tumblers and remove the obstructions to the bolt's passage. Mr. Hobbs then made a false key, with a single thin projection, corresponding to the thickness and height of the final step only of the true key. Its proper length of course the key-hole would give him. With this he could reach the talon of the bolt, and by turning it round, as in the act of unlocking, could get the stud to press in the direction he wanted. The false key had no bow, or cross-piece at the top, for the hand to grasp in order to turn it, but its plain stem was filed to a square at the end, to receive the eye of a lever which answered the same purpose, and which, being extended to a considerable length, admitted of a weight being hung upon it to maintain the pressure at a constant degree of tension. Thus one part of the object (the tightening of the stud against the levers) was accomplished. For the purpose of feeling and lifting the levers, a second key, also furnished with a narrow bitt, corresponding to a single step of the true key, and the

stem of which was a tube throughout, was slipped on to the stem of the other key before the lever was affixed. This second key was furnished with cross-pieces which served the purpose of a bow, and could be turned round easily upon the stem of the first. The *modus operandi* is now clear. The second key was pushed forward until its bitt entered the key-hole, and with it the levers were felt and lifted cautiously, and the lock picked.

The lock of the Messrs. Chubb, which Mr. Hobbs publicly picked with the instrument described above, was furnished with their patent detector spring, which we have not yet described. It was fixed immediately over the levers, near the hinged ends, and its action was so contrived that if any one of the tumblers were overlifted ever so little, so that the stud entered the lower slot, the detector spring would seize it, and hold it there firmly, so that the bolt could not be moved either way until the spring was released. The true key would not undo the lock while the detector was on, but it would release the detector on being turned the reverse way. This was a very useful contrivance, as showing when the lock had been tampered with, and stood terribly in the way of a clumsy manipulator who was trying to pick the lock by the tentative process. We may be sure that Mr. Hobbs conducted his operations with such delicacy and precision, that he stood in no fear of the detector; he would be sure *not* to overlift the tumblers; but independently of that, his sagacity soon discovered how the detector might really be made to help him. If the position of the detector could be ascertained from the outside, which might be done by drilling, and if a piece of metal could be so inserted as to hold the detector down, the tumblers could not be overlifted, and the picking of the lock became an easy matter.

Another and more effectual defence against tentative picking was the introduction of false notches. The picker, on lifting cautiously a tight lever, felt it suddenly become relieved, and concluded that the transverse slot had been entered; when, in truth, the stud had only fallen into a slight recess, cut out of the side of the upright slot. This puzzled the picklock amazingly, as he never could make sure when he was right; and although the lock was not absolutely impregnable to him, it was practically so, owing to the time it would take to pick it.

But Mr. Hobbs himself introduced a neat little invention which met the danger in a truly scientific manner. Instead of making his stud a fixture, as in other locks—*i.e.*, riveted to the bolt, and moving rigidly along with it—he fixed it upon a small movable platform, which was let into the substance of the bolt, and turned upon a central pin. When the lock was acted upon with the true key, the stud passed freely enough from one slot into another, and did not move from its position; but when stress was brought to bear upon it, as in pressure applied for the purpose of tentative picking, the stud moved slowly round with its platform, which carried with it a dog which hooked into another part of the works, and pinned the bolt in its place.

The highest application of the tumbler principle is, perhaps, to be found in the parautoptic lock, so called from a Greek word signifying *concealed from view*, patented by Messrs. Day and Newell, of New York, and introduced to this country by Mr. Hobbs. It would be impossible to convey any idea of it by a merely written description; we must be content, therefore, to simply state its capabilities. It has the power of re-adjusting itself to any combination that its owner pleases, and to as many as he pleases. The bitt of the key, with its steps, is formed of a series of movable pieces, which the owner can re-arrange, or substitute others for, at pleasure. When once locked, which may be done with any combination, only the same combination will unlock it, and thus it may be set to a different combination each time. An impression in wax of the true key would, therefore, be of no use to the burglar, as the true key might alter its features from day to day—an advantage which was not possessed by any other tumbler lock. The machinery of the lock was necessarily complicated, and the price high, but that, where absolute safety was the object, was of no consequence.

We have now brought down our survey of lock construction to the point when another new principle comes under our consideration—that of the Bramah. We have not been governed by dates in the order of introducing the inventions here described, but have simply endeavoured to place them in such order as would assist them to illustrate each other, and convey clear ideas to the reader. The same method will be pursued in a concluding paper.

TECHNICAL DRAWING.—LXV.

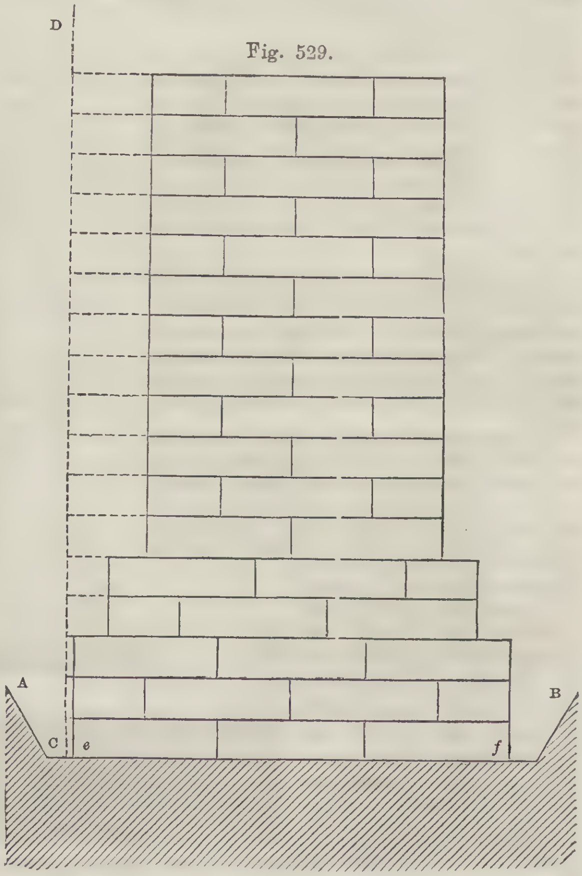
DRAWING FOR BRICKLAYERS.

FOOTINGS OF BRICK WALLS.

THE base of a brick wall is technically called the "footing,"* and it should always exceed the thickness of the body of the wall. The custom is to diminish the base of the wall from the bottom upwards by small steps or offsets of a quarter of a brick on each side, thus making half a brick in all saved upon each projecting course. Sometimes smaller offsets have been used, but none greater should be employed, excepting in walls of one brick thickness.

The offsets are sometimes laid out in every successive course, which in brickwork does not exceed three inches in height for each step, until the proposed diminution is obtained. Sometimes they are laid out in every second or third course, according to circumstances.

Fig. 529.



The example (Fig. 529) represents a section of a wall of two bricks in thickness, having a base of three bricks thick, which has been diminished in the manner described in the opening paragraph of this lesson.

The offsets at the base of a building are usually covered with earth, by the filling in of the original trench excavated for the foundation; but sometimes there may be offsets in a higher level, in which case there is seldom more than one externally, which is usually at a moderate distance from the ground. The others are internal.

The propriety of giving to the walls of buildings a footing such as has been described, arises from the well-known circumstance that the stability of bodies depends in a great measure upon the magnitude of their base. To add to the security of very extensive walls serving as enclosures, they are usually built not only with footings, but also with buttresses at moderate

* See lessons on "Building Construction," Vol. I., page 172.

intervals apart, as may be observed in the walls of dockyards, etc. In common buildings, the several walls serve as buttresses to one another; still, footings are absolutely necessary in bad soil, and are so useful, and add so much to the stability of the structure, that they cannot with propriety be dispensed with under any circumstances, although in some cases their projection may be diminished.

The method of drawing the example given in the preceding page is so very simple that only very few instructions will be required.

Having drawn the trench, A B, draw any perpendicular, as C D, set off on it the heights of the bricks, and draw horizontal lines from these points for the various courses of brickwork. By this plan all measuring and fraying of the paper by alterations is avoided. It will be seen that the first footings are carried up through three courses. Therefore, having marked the width of the base—viz., three bricks—draw perpendiculars at each side, *e f*, thus completing the rectangle, which forms, as it were, the first block of the footings.

The first and third courses of this block are laid alike—viz., three bricks placed so that their length passes through the entire thickness of the footing; the second course consists of two whole bricks in the interior, and one half brick in each side. These are not, however, *half* bricks, but the *ends* of whole bricks laid at right angles to the other two courses—that is, having their length parallel to the surface of the wall.

The next footing is to be drawn in the same manner, the containing rectangle being kept at a quarter of a brick within the lower block, thus leaving the present footing two and a-half bricks. These are laid so that the half (or rather the end) brick is on the one side of the wall in the first course, and on the other in the second.

The wall itself is two bricks thick, and is laid so that the courses consist alternately of two whole bricks, and one whole and two end bricks.

The student is here reminded that it is most important that brick walls should be kept perfectly vertical, for it will be evident that if a wall at the bottom is in the slightest degree "out," the evil (like every other) will go on increasing; the top will gradually extend beyond the foundation and fall. But this is not all; the wall must be kept "plumb," which term does not necessarily mean upright, but a plane surface. Thus a wall may be slanting, as a bank or side of a tower, which tapers towards the top. But in whatever position it may be, it must be kept plumb, and the plumb-rule may not only be used for this purpose, but to keep the joints over each other. This is generally termed "keeping the perpends." Now as this is so important a point in practice, it is of course necessary to be observed in drawing a wall, and therefore the joints which fall above each other should be drawn whilst the set-square is placed for any one of them, for the same line will be required in continuation in each of the alternate spaces or courses.

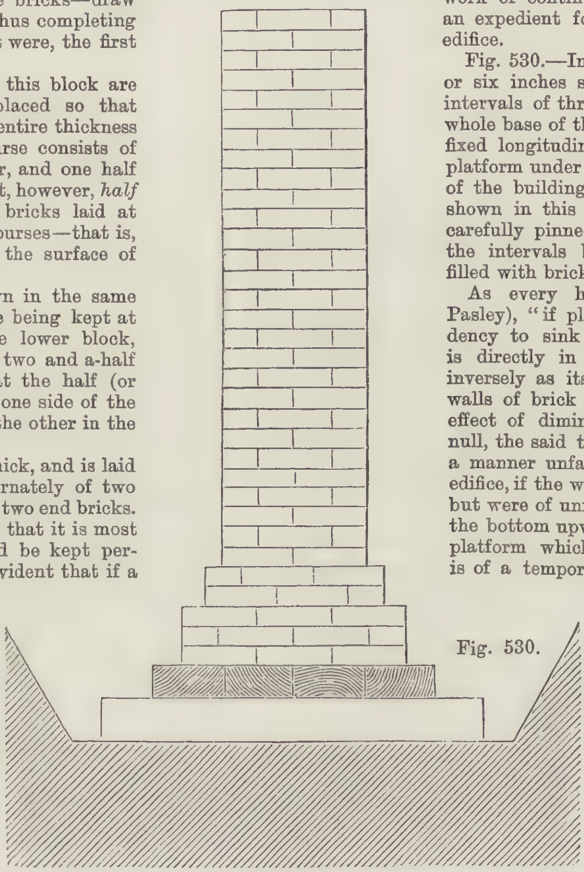


Fig. 530.

FOUNDATIONS OF BUILDINGS IN UNFAVOURABLE SOIL—PILED FOUNDATIONS.

It has been before observed that the soil upon which a building of any importance is to be erected should always be well examined before the work is commenced, which may be done by striking it to ascertain if it sounds hollow, and then by boring it in various parts with an earth-borer. Small shafts, cut at certain intervals, may also answer the purpose of discovering the nature and depth of several strata when the ground is not of uniform consistency.

When the soil is partly good and partly bad, the latter may be cut deeper until good soil is obtained, if it can be found at moderate depth, and thus the footings may be built as in irregular ground—not on one continued level, but in steps or terraces.

When the soil is all of the same quality, but looser in some parts than in others, ramming it well in the loose parts has been considered a very useful and, sometimes, a sufficient precaution; and this method of treating the soil is particularly recommended by some of the French engineers of the greatest eminence.

Even in buildings erected of bricks it has been common to commence the foundation with flat stones, placing the largest as regularly as possible, filling in the intervals with smaller ones, and ramming them down.

When the soil is of a middling quality, not absolutely good, nor yet altogether unsound and treacherous, a grating or network of continued woodwork is often used as an expedient for ensuring the stability of an edifice.

Fig. 530.—In this case, sleepers of about five or six inches square are laid transversely, at intervals of three or four feet apart, under the whole base of the intended wall. Over these are fixed longitudinal planks forming a continued platform under the whole foundation of the walls of the building, as represented in the section shown in this example. The planks must be carefully pinned down upon the sleepers, and the intervals between the latter are usually filled with bricks or stones—not with earth.

As every heavy body (says Sir Charles Pasley), "if placed upon soft soil, has a tendency to sink more or less, which tendency is directly in proportion to its weight, but inversely as its base, the footing given to the walls of brick buildings has in such soil the effect of diminishing, or altogether rendering null, the said tendency, which might operate in a manner unfavourable to the stability of the edifice, if the walls had no such increase of base, but were of uniform thickness throughout, from the bottom upwards. In respect to the wooden platform which has been described, its use is of a temporary nature, as it merely serves to prevent the brickwork, if it sinks at all, from sinking unequally whilst the mortar is yet soft, or the work green, as it is technically termed. After a certain number of years, when the mortar and bricks shall have become completely consolidated into one compact mass, they are no longer liable to separate, even if the woodwork underneath could be removed."

It will perhaps be scarcely necessary to remark that the base of every brick wall of the same height and thickness, or, in other words, of the same weight, should be greater in direct proportion to the softness of the soil on which it is built; also that the projecting parts of the footing of a wall should have a certain depth to give them solidity, otherwise the greater weight upon the central part of the base might fracture the bottom of the wall, and thereby render the footing useless; for this reason it is desirable that the offsets, when there are several, should not follow in every succeeding course, but at greater intervals apart, as already mentioned. Moreover, it is advisable in erecting a building in middling soil upon a wooden platform, such as has been described, either to make all the walls of equal thickness, and consequently of equal weight throughout; or, if that arrangement would not be convenient, to give the thicker wall the greater base in direct proportion to its weight.

In this example the wooden platform is to be drawn first, and the work is then to be proceeded with as in the former study. For illustrations of platforms laid on network of timber the student is referred to pages 47 and 56, Vol. I., of THE TECHNICAL EDUCATOR.

SILK CULTURE.—V.

By Alexander Wallace, M.D.

WILD RACES OF SILKWORMS — THE BOMBYX YAMA-MAÏ — DISEASES OF THE WORM—ITS CULTURAL TREATMENT—THE QUALITY OF ITS SILK.

Thus far have we briefly set forth the culture of the mulberry silkworm, touching but scantily on many points which, did time and space allow, might well demand explanation in detail. We must omit almost entirely to mention those vast tracts in our colonies which, most admirably fitted by Nature to mulberry silk culture, lie waiting the time for their resources to be developed; also the special kinds of mulberry-trees, and the special races of silkworms which may there be most profitably introduced; and to supply suitable instructions for colonial sericulture, where, favoured by climatic salubrity, but devoid of artificial help, the colonist often with the rudest possible appliances brings his labour to a successful termination almost in the open air. We must pass over likewise what has been already done in Egypt, California, Chili, Turkestan, Australia, nay, even in England itself, where much might be cited in furtherance of the views held by practical sericulturists of repute abroad, viz., M. Guérin Mèneville and M. Taurigna, etc., that England is especially fitted, on account of its cool climate, for the production of healthy grain. We must omit likewise at present all reference to silk-reeling, an industry which, in the opinion of many, might easily be followed in England, not merely to the benefit of the women and children employed therein, who would thus find another opening for work afforded them—no small boon in many agricultural towns—but to the advantage also of the weaver and manufacturer, who thus might obtain at home the exact quality of silk required for their machinery, and the colonist as well, who might thus find a home market for his produce, instead of sending it, as at present, to Marseilles. Omitting these and other points of great interest, in the hope of being permitted at some future time to touch upon them, we must hurry on to dilate somewhat on the other silkworm races mentioned in our first paper, generally known as wild races, in opposition to the domesticated *Bombyx mori*, since all these found wild in their native habitats have never yet been entirely subjugated by man.

First and foremost among these, probably in point of beauty, but certainly in point of value, is the Japanese oak-feeding *Bombyx Yama-Maï*, illustrated on page 177.

What we know of the past history of this valuable race is as follows:—For many years the Japanese had cultivated an oak-feeding silkworm as well as the mulberry worm, and according to some writers the profits arising from this species exclusively belonged to the royal family; according to others, its silken produce was employed to make the rich vestments of the imperial family. In either case this valuable species was so highly esteemed that the punishment of death was by law inflicted on any one who exported the eggs. This, then, explains the reason why for so many years this species was unknown to our naturalists and its silk to our merchants. It was not till the beginning of the year 1861 that, during the presence of the French fleet in the Japanese waters, the attention of M. Duchesne de Bellecourt, French Consul-General and Chargé d'Affaires at Japan, having been directed to the beauty of the silken fabrics produced from the cocoons of the *Bombyx Yama-Maï*, he was enabled to obtain some eggs, which were transmitted to the Imperial Government of France, and finally entrusted to the hands of the Imperial Society of Acclimatisation. Now, fortunately, there is no difficulty in procuring eggs of this species in Japan, except that sometimes wooden eggs are fabricated to deceive unwary customers. The eggs first sent over

Fig. 6.—CATERPILLAR, MOTH, COCOON, AND CHRYSALIS OF BOMBYX CECROPIA.

to Europe were carefully tended in the museum at the Jardin des Plantes at Paris. Unfortunately, nothing was known of the habit of the insect, not even its food-plant; when, therefore, the first eggs hatched out, about the 15th of March, 1861, the young worms refused all the leaves presented to them, and perished. But in the beginning of April an oak (*Quercus cuspidata*) placed under glass having put out some leaves, these were eaten by the young worms, and hope was now entertained of rearing them. The President of the Society of Acclimatisation immediately obtained from Toulon and Hyères, in the south of France, young oak-leaves, with which the baby worms were fed from the 9th of April till the time when the oaks at Paris had sufficient foliage. These worms, about forty in all, grew well up to their fourth moult, but being in the serpent-house, the high temperature and close atmosphere proved injurious to them; at least it was probably from that cause that in their fifth stage all the worms (five only excepted) died off in a few days of the same sickness, a black liquid oozing through the pores of the skin. The remaining five made imperfect cocoons, but no moth hatched out. Happily a few eggs of the same batch had been sent to the learned entomologist, M. Guérin Mèneville, that he might name the species; of the few worms hatched out of those eggs one only was born sufficiently late to obtain oak-leaves. It was sent to M. Année, at Passy, where it throve under glass near a door which was always open. It spun a very handsome cocoon, whence a female moth emerged. This attempt, insufficient, unfortunately, to propagate the race, yet sufficed for M. Guérin Mèneville to give a name to the new insect, permitted a study of its habits, of its beauty as a larva, of the size, form, and colour of the cocoon, of the suppleness, brilliancy, and elasticity of the silken fibre, and, lastly, of the physiological and scientific character of the moth. The chance of a second experiment under such circumstances was greatly to be desired; therefore, M. Eugène Simon, the Agricultural Commissioner of the French Government in China and Japan, received a special mission to search out and send over eggs of the *Yama-Maï*. But the Japanese law, entailing death on any one detected in exporting the eggs, was for some time an insurmountable difficulty, and M. Simon was obliged to leave Japan with his mission unexecuted. But happily he had made the acquaintance of a *savant* devoted to the cause, M. Pompe van Meedervoort, medical officer in the Dutch navy, and Director of the Imperial School of Medicine at Nagasaki, who, seeing the importance of such a result, was able most fortunately to attain it. To M. Pompe van Meedervoort Europe owes the possession of this valuable species, the *Bombyx Yama-Maï*. Early in January, 1863, this *savant* returned to Holland with a parcel of eggs. The greater part of these were sent, according to a promise made to M. Simon, to the French Government, and the Government handed the eggs to the Imperial Society of Acclimatisation, and the Society to M. Guérin Mèneville for distribution among the members, etc.; some were retained by M. Pompe van Meedervoort for his friends and his country; and the remainder was given to M. Guérin Mèneville, through the kindness of a Dr. Blecker, for distribution among those naturalists and sericulturists who were not members of the Imperial Society of Acclimatisation. Subjoined is the translation of a notice published by M. Pompe van Meedervoort, relative to the introduction of the *Yama-Maï* into Europe :—

"In 1862 I had the honour to make the acquaintance of M. Eugène Simon. He informed me of the great value of the *Bombyx Yama-Maï*, and together we made every effort, but in vain, to procure eggs of this species; we were told it was absolutely impossible to obtain them. M. Simon being obliged to return, I made him a promise before he left to continue my efforts, and, in case of success, to offer the eggs to the French Government. But the more I tried, the more I saw how difficult, if not impossible, was the attempt. I applied in vain to the Japanese merchants, the silk-growers, to many native naturalists with whom I was on friendly terms, lastly to the government, but all in vain. The reply was, 'The penalty of death is inflicted on any one who may export these eggs.' Another idea then possessed me—to apply to one of my pupils. As the Principal of the Imperial School of Medicine at Nagasaki, I was surrounded with students from the different provinces of Japan, and amongst others from the provinces of Echizen and Vigo, or Hiogo, where alone the *Yama-Maï* silkworms are reared. One of these youths, who had on several occasions given me proofs of his extraordinary devotion, was selected by me for the purpose; to him I explained the whole affair, and proposed that he should go to Vigo at my expense, in order to collect and send me as many eggs as possible. This brave young man, whose name I have promised solemnly never to divulge, started on the morrow, and after an absence of fifteen days secretly sent me the eggs, which he had collected with much difficulty and danger to himself. He told me that no one suspected the object of his journey; that was in October, 1862. My mission to Japan was finished November 1st, 1862. I started for Europe by the English mail packet, and undertook the charge of carrying these eggs to Europe. This was by no means an easy matter on board a steam-ship in the tropics. If the eggs were kept in the cabin a great risk of their premature hatching was incurred, for the temperature there in the month of November is above 95° F., and in the Red Sea 105° and more. I followed the advice of M. Simon, and placed the eggs in the ice-box on board ship, though often but little ice was therein. To this precaution is due in a great measure their safe arrival in Europe in good condition. I arrived at the Hague early in January, 1863, and at once sent out the eggs; the greater part was sent to the French Government and to the Imperial Society of Acclimatisation, according to promise I had made to my friend M. Simon."

From this beginning the new species spread over Europe. Since 1865 several trials have been made in England to rear the species, but as yet unsuccessfully. The same want of good fortune has attended many trials in France, Holland, and other countries; but several gentlemen have attained success even on a large scale. Thus M. Guérin Mèneville, at the Imperial farm at Vincennes, M. Chavannes, Professor of Zoology at the Academy of Lausanne, M. Personnat, at Laval, France, have succeeded in rearing thousands of cocoons. In 1869 the Baron de Bretton, in his woods in Moravia, raised more than 27,000 cocoons, and pursues the culture with considerable success. In 1871, in France and Germany, many thousands of cocoons were reared.

The great drawback to the cultivation of the *Yama-Maï* silkworm in this country is the prevalence of disease. I have had eggs, both sent from Japan and laid in this country, of the healthiest possible aspect; the young larvæ when born seem perfectly healthy, and thrive for a time; yet year after year I have seen the whole brood swept off in a most mysterious and hitherto unexplained manner; and my experience is similar to that of others, both here and on the Continent. From my experience I am led to think the worm is liable to three forms of disease.

First. In early life, in the first or second age, a small percentage of worms are apt to turn yellow, and be affected with diarrhœa; they become soft and die. This form of disease has been described by French writers on silkworms as the jaundice. I believe it is due entirely to want of vitality, as I have noticed that the smaller, later born, and weakly worms are chiefly affected thereby.

Second. In mid-age another malady, caused I believe entirely by too high a temperature, attacks the worms. The first indications are that the vivid beautiful green tint becomes dull and opaque, the skin tightens at the flexures of the segments, a whitish tint is now observed in patches; sometimes, but rarely, some minute dusky specks are visible at the flexures; the larvæ are flaccid, and eat but little. If muscular movement be made, as on the approach of a visitor, the skin cracks, a pale turbid green fluid issues, the worm shrinks, shrivels, and decomposes rapidly.

A third form attacks those nearly full grown or about to spin. Minute dusky specks are visible on the whole body; these rapidly increase and coalesce into brown blotches; the beautiful deep green colour turns into a muddy green-yellow, diarrhœa ensues; the larvæ cease to eat, the claspers retain their grasp; but all muscular power being lost, the body hangs an inert sack, full of decomposing fluids, which burst out at the most convenient spot. In a few brief hours nothing remains of the fine handsome larvæ but dry brown skins.

My own opinion is that shade, moisture, and a cool, even temperature, with very free ventilation, are necessary to the welfare of this creature. In its early life, in May, a temperature of 50° to 55°, or 60°, is desirable, to be increased during June to 65° to 75°; but I think a higher temperature endangers the

safety of the worm; and this I believe to be the chief reason why it has been reared successfully on the Continent for several seasons, and then suddenly and entirely failed.

It is evident that the third form of disease is connected with the secretion of silk in the interior of the larvæ. We find in many cases that the worms pass the spinning-time and make no effort, others spin a little silk and then die, others when examined have no silk within them, others spin a weak cocoon and then die: either, therefore, some necessary element is deficient, or some disturbing cause prevents the formation of the silk. To this point it will be necessary for future observers to pay especial attention.

I will now mention a few points of interest connected with this silkworm. First, it differs from the *Ailanthus* silkworm, *Bombyx Cynthia*, and resembles the mulberry worm *Bombyx mori*, in passing the winter in the egg state, so that the year commences with the egg state, whereas in *Bombyx Cynthia* the perfect insect first makes its appearance in the early summer, after passing the winter in the cocoon stage. A curious circumstance connected with the egg etate of this insect has been observed by M. Guérin Mèneville, that the young larva is fully developed a month after deposition of the egg, and that he lies during the winter perdu within the shell, in a dormant condition, until a vernal temperature and moisture awake him to the active duties of life.

Immediately after birth the young worm, which is handsomely clothed in a yellow jacket slashed with dark velvet lines, is said to expand in volume in consequence of the air inspired, but probably also because the tubercles and spines, which were previously flattened down inside the egg, are now erect and prominent. The statement that the worm seems to grow even before it has eaten is quite correct.

The larva undergoes the same number of moults as the mulberry worm, but assumes quite a different aspect, being adorned with a beautiful vivid green tint, with blue tubercles and some silver spots on each side.

It is erratic at first, but soon settles down to its food, especially if able to obtain drink; for this peculiar larva, quite unlike the mulberry worm, requires a considerable supply of fluid. It is desirable in in-door culture to moisten the leaves twice a day. The worms put down their heads to the drops of water, eagerly imbibe them, and afterwards repose in the attitude so common to all larvæ of *Bombycidæ*, the head, fore-legs, and fore part of the body tucked in and contracted, but elevated in the air in a curve, the hind claspers firmly attached to the twig.

This larva cannot be educated on trays like the mulberry worm, but requires to rest on the twigs of the oak-boughs on which it feeds.

One great climatic difference exists between this country and Japan, viz., the rainy season, which, as we are told, generally commences about the 5th of May. I have been informed by those who have resided in Japan that about that time it rains regularly, without intermission, heavily for several weeks; this coincides with one account given by the Japanese of its culture, "that during the rain the boughs keep quite fresh." It would therefore seem that at least rainy seasons are favourable to the *Yama-Maï* larvæ, and this point is the only one which seems to me to throw any doubt on the probable success of the cultivation of the worm in Europe. Ireland would, therefore, seem to be a country specially favourable; for the same reason the north-west coast of England and Scotland, as perhaps also the south-west coast, would be specially favourable; whereas the eastern counties are probably the worst.

The cocoons of *Bombyx Yama-Maï* are of a green tint, are spun up in the oak leaves, and weigh 7 to 8 grammes each; whereas the cocoons of *Bombyx mori* weigh 2½ to 3 grammes each. The silken material is in the same proportion, viz., 70 to 80 centigrammes; that of the mulberry 25 to 35 centigrammes.

To estimate the resultant silk in weight from a given number of cocoons, it is customary to allow 12 lb. of cocoons to make 1 lb. of silk, allowing for waste, etc. The *Yama-Maï* cocoon will have a slight advantage in this over the mulberry cocoon, owing to its greater size and less waste. It is wound as easily as that of the mulberry cocoons, from end to end in a continuous thread, when placed in boiling water. There are two qualities of silk, the exterior layers of the cocoons being stouter and of a greenish-yellow tint, and the interior of a fine texture and white colour; hence the winding is divided into two operations, so as to preserve the two qualities distinct. Regarding the quality of the silk, M. Gelot pronounced the following opinion at the International Exhibition of Insects at Paris, 1865:—

"The silk of *Bombyx Yama-Maï* seems to me to occupy, after that of the mulberry worm, the highest rank. It is, perhaps, a trifle less fine, but is quite as brilliant as that silk. I believe in many cases it might be employed instead of it; and that if we succeed in acclimatising its production on a large scale, it might make up for our deficiency in the production of mulberry silk. The clear green tint which it naturally possesses is no obstacle to the various shades of dye, for it disappears with washing and becomes white. The rapid development of this valuable branch of industry cannot be too highly encouraged." Elsewhere we read: "Several bales of *Yama-Maï* silk have been purchased at Yokohama, Japan, at 550 piastres the picul (60 kilogrammes). As the piastre is equal to 6 francs, these raw silks fetch at the place of production 55 francs the kilogramme. At the same time and place were sold bales of ordinary silk at 600 to 612 piastres per picul, or 60 to 61 francs per kilogramme, about 25s. per lb."

It will be sufficiently evident, from what has already been stated, that the possession and acclimatisation of a very valuable race of silkworms in Europe is at the present time *un fait accompli;* and that although up to this time we have not succeeded in England in rearing this worm, yet we have good grounds for expectation that as a greater knowledge of its habits and of the precautions necessary to a successful cultivation are diffused, we shall find many ready to take up this new culture in Great Britain and Ireland.

CIVIL ENGINEERING.—XVII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES.

THE necessity for enabling ships to avoid dangers from rocks, and to safely enter harbours during the night, must have been obvious to the very first men who undertook a voyage during which land was lost sight of: we may, therefore, reasonably infer that lighthouses or light-giving beacons were coeval with navigation. Moreover, it is obvious that the position of these beacons must have been well known, and would have occupied fixed positions.

We have very early and authentic accounts of structures erected by the ancients with the object stated, of most magnificent designs and dimensions. Indeed, in all the engineering works of the ancients we behold the marvellous combination of beauty, strength, and utility, which as regards the first qualification is sadly wanting in modern structures. The Pharos which stood in the centre of the breakwater guarding the entrance to the port of Ostia may justly claim a few words of notice. Its description reads almost like a fable. It consisted of four distinct storeys, of which the lower three were decorated with orders of architecture, the bottom being the Doric, the second the Ionic, and the third the Corinthian. The fourth or upper storey was surmounted by a fire, which was always lighted at the approach of night, and which, from the height of the structure, could be seen at a great distance. The building was equally convenient as a residence for the officers and men who had charge of the port. Immediately in front of this Pharos stood a colossal statue of the Emperor Claudius.

A still grander, although less architectural, beacon was erected at Alexandria upon the island of Pharos in the reign of Ptolemy. This structure was built upon a rock at the eastern extremity of the island. It was 450 feet in height, and it is stated that the fire which was kept burning at night upon its summit could be seen at a distance of 100 miles; this, however, is doubtful. The Pharos was formed of several storeys, decreasing in dimensions towards the top. The ground floor was hexagonal; the second and third storeys were of the same form; the fourth was square, with a round tower at each angle; and the fifth circular, which was continued to the top or lantern, to which a winding staircase conducted. This immense structure was built entirely of stone.

Descending to more modern periods, we may refer with some degree of pride to the many excellent lighthouses erected upon different points of our own coasts at various times, commencing

about the year 1676. The whole of the beacons and "signs for the sea," as these structures were called, situated upon the English coast, were placed under the entire control of the corporation of the Trinity House by Queen Elizabeth; those in Scotland under the Commissioners for Northern Lighthouses, and those in Ireland under the superintendence of the Ballast Board. These three bodies collectively have under their supervision upwards of 200 lighthouses and floating lights.

One of the earliest erected by the Trinity Board was at Lowestoft, on the eastern coast. It is a circular tower of brick, 40 feet high and 20 feet in diameter. Its upper storey was originally glazed all round, and the light was obtained by a coal fire. This arrangement, however, was altered by the Trinity House in 1778, and a more modern and effective lantern was substituted.

The character and mode of construction of a lighthouse will differ essentially according to the position it has to occupy. It may form an efficient beacon if standing upon a projecting headland, and in no way exposed to the violence of the sea; in such a case not more than ordinary precautions need be adopted in its construction. Very different, however, will be the case when the lighthouse has to stand upon some bare isolated rock, removed many miles from any shore, and exposed to the full fury of wind and wave. Then all the skill of the engineer has to be brought into play, and every mechanical device has to be enlisted to enable the friendly beacon to retain its hold against huge mountains of water hurled at it and over it by the tempest's violence.

One of the earliest of modern lighthouses, and one of the most magnificent structures of the kind in the world, is situated at Cordouan, upon a rock at the mouth of the Garonne, the credit of it being due to Louis de Foix, a French engineer. It was commenced in 1584, and occupied twenty-six years in erection. The tower is 169 feet high from its foundations. The island rock upon which it stands is dry at low water, but entirely covered by the tide at high water. The base of the structure is a circle of 135 feet in diameter, and consists of a mass of masonry, solid, with the exception of the approach steps and the fresh-water cistern, and is carried to a height of 20 feet, terminating in a level platform, upon which the tower stands. This solid base is bounded by sloping sides, reducing the diameter of the platform to 125 feet. It is surrounded by a massive wall for protection against the violence of the surf, 12 feet 6 inches thick at the base and 11 feet at the top, and 12 feet high. The tower itself is 50 feet in diameter at the base, and consists of four storeys. These are highly decorated externally. The lowest is of the Doric order, the second of the Ionic, the third of the Corinthian, and the highest or lantern of the Composite. The original lantern was destroyed in 1727, and a new one of iron substituted. This was effected by M. Betri, who contrived a sort of iron cage or lantern formed of four pillars which supported a cupola, finished with a ball and vane. The lantern was open to admit of the free escape of the smoke from the burners. The circular ceiling was formed into a hollow funnel, the top of which was bent three feet downwards, and being covered with polished tin plates, it served as a reflecting surface for throwing the rays of light to a greater distance. This rude form of reflector became the original for the introduction of a more perfect contrivance which was introduced by M. Borda about the year 1780. His arrangement consisted of an argand lamp which was placed in front of a parabolic mirror. The mirror was formed of a sheet of copper plated with silver and burnished, having a focal length of about four inches, and a diameter of 21 inches. The form of the perfect parabola causes the rays thrown upon its surface from a point of light placed in its focus to issue in parallel lines, so that the area of the reflected beam will not exceed the area of the mirror, and hence it becomes necessary to place the burner a short distance out of the focus, whereby the rays become diverted and spread over a greater space. As a work of art, the lighthouse at Cordouan occupies a foremost position: we shall now have occasion to call attention to some other structures of the kind which, as works of engineering skill, will compare with any either of ancient or modern date.

There exists in the English Channel, in the route of thousands of ships passing and re-passing every year, a group of rocks of a stone called in Cornwall "moorstone," being either gneiss or granite. It lies nearly due south of the promontory called the Ramhead, from which—the nearest point of land—it is about ten miles distant. This group, called the "Eddystone," from the set of the tides and the violence of the eddies and currents which exist there, has always proved a source of extreme danger to shipping, being nearly submerged at high water; and it is a fact that previous to the erection of a beacon upon them, many wrecks occurred upon the rocks surrounding the Channel Islands, owing to the fear entertained by sailors of the Eddystone, which induced them to choose a more southerly course to avoid them. It is, therefore, not surprising that a very early attempt was made to fix a structure upon these rocks which should be capable of resisting the fearful violence of the storms which, coming from the west and south-west, hurled their full force upon this dangerous reef.

The first attempt to erect a lighthouse here was made in 1696 by Winstanley, who worked under the powers invested in the Corporation of the Trinity House by Queen Elizabeth. Winstanley appears to have been an amateur engineer, although certainly a man of considerable genius and capacity, and the fact that he attempted a lodgment at all upon the Eddystone, proves him to have been possessed of great courage and strength of purpose.

Winstanley's lighthouse occupied from three to four years in building. Owing to the exposed position of the rocks, and the almost continual surf which breaks over them, great difficulty and interruption was experienced in fixing the lower portion of the work. The plan adopted was to bore holes in the rock in certain positions, and to fix iron rods therein to form the main-stay for the masonry which was subsequently built around them. The whole of one summer was occupied in boring twelve holes, each 3½ inches in diameter, in a circle about 13 feet across, and securely fixing the iron rods in them. During the second summer a solid mass of masonry 14 feet in diameter, and 12 feet high from the upper surface of the sloping ledge of rock, and 17 feet high from the lower part, was built up around the twelve iron rods. During the third year the upper works were completed. The building as it then stood was 80 feet from the foundation to the vane. It is probable that the upper part of this building, which contained several storeys, was constructed of timber.

Winstanley ventured to remain in the completed lighthouse with several workmen for a considerable period during the summer of 1698, but a severe storm arose which dashed water into the building and did considerable mischief. This, however, was repaired, and a light exhibited for the first time in November of the same year. During the following year it was deemed necessary to strengthen the work; and whilst the diameter of the base was increased to 24 feet, the masonry was carried up solid to a height of nearly 20 feet. This building—which, from the print published by the architect, seems rather to have resembled a Chinese pagoda than a lighthouse—withstood the force of wind and weather for four years, and there is a well-known statement that Winstanley was so satisfied with the stability of his structure, that he expressed a desire to be in it during the fiercest storm that ever blew. He had his desire, for in November, 1703, a terrific tempest arose whilst he was at the rock superintending some repairs, and when the morning of the 27th of that month broke, nothing remained of the lighthouse or of the unfortunate inmates. The rock had been swept bare.

Winstanley's attempt had, however, proved the possibility of planting a structure upon the Eddystone capable of withstanding ordinary weather, and it was hoped that, by adopting greater precautions, a permanent building might be fixed there.

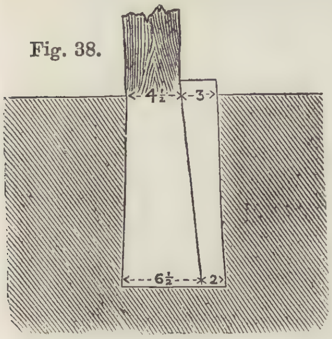
John Rudyerd, a London silk mercer, was in 1706 employed to re-construct the lighthouse. The extreme necessity for such a building was not long in becoming evident, for very shortly after the first structure had been swept away, a splendid ship, the *Winchelsea*, was wrecked upon the dangerous reef, and almost all on board perished.

Rudyerd was not an engineer, at least not by education; this profession did not exist as such in his time, but he formed one amongst other bold, self-taught men who have existed in almost all ages, and whose genius is only brought to the front when some necessity for its development arises.

The second building was, like the first, erected under the auspices of the Trinity House. Rudyerd was, however, not employed directly by the Brethren, but by a Captain Lovet, who under the authority of an Act of Parliament was permitted to take a lease of the intended lighthouse, with its tolls and perquisites, for ninety-nine years. Rudyerd seems carefully to have

studied his subject before commencing work. He adopted the circle as the form for the plan of his building, and carried up the structure as a cone, thus selecting the form which offered the least resistance to the force of the elements from whatever quarter they burst upon it. Smeaton has left us in his narrative some interesting facts connected with Rudyerd's engineering arrangements. From him we learn the following:—A number of holes were bored or "jumped" in the rock, the formation of the holes being peculiar. The object of the designer was to cut wedge-shaped holes, the widest end of the wedge being downwards, and to insert iron bolts into these holes, keying them at the bottom so as to spread them out after their insertion, whereby it became impossible to withdraw them. This arrangement was, in fact, none other than the well-known engineering contrivance called a "lewis." The method adopted was to bore two holes $2\frac{1}{4}$ inches in diameter in a sloping direction, that is to say, they were $7\frac{1}{2}$ inches apart at the surface of the rock, and $8\frac{1}{2}$ inches at the bottom, the depth being about 16 inches. A third hole was bored between these vertically, and the rock between them was then cut away by suitably-shaped tools. By this means a hole of a dovetailed shape was obtained $2\frac{1}{2}$ inches wide, $7\frac{1}{2}$ inches broad at top, $8\frac{1}{2}$ inches wide at the bottom, and 16 inches deep. The iron branches inserted into these holes were specially forged for their positions. They were $4\frac{1}{2}$ inches broad at the surface of the rock, and $6\frac{1}{2}$ inches broad at the bottom, so that a space was left upon one side after they were introduced into the hole of 3 inches at top and 2 inches at bottom. Fig. 38 will explain the arrangement, and will show how secure the irons must have been when so fixed. To make assurance doubly sure, however, a quantity of melted tallow was poured into each hole, and the iron and key heated to a blue heat were then inserted, and the key driven home; then, whilst the iron remained warm, a quantity of red-hot pewter was poured in, which being heavier than the tallow, drove it out. So firm and substantial was the entire arrangement, that when, many years afterwards, the irons were cut out, the iron, pewter, and tallow were found unaffected by the sea-water, which appeared never to have penetrated the holes.

Fig. 38.



After the irons were fixed, a layer of squared oak timber was laid upon the lowest level of the rock included in the plan, and of sufficient thickness to reach to the next higher level. Over this was placed another layer transversely, and over this others, every alternate layer being laid across the one next below it. In this manner a solid mass of oak was piled up, the top of which was two courses higher than the highest part of the rock, and the whole mass was securely tree-nailed together. In the centre of this timber was placed an upright mast securely fixed to the rock by strong irons, and carried up 33 feet, or more than half-way up the intended height of the building. Altogether there were thirty-six irons inserted into the rock, and in each of these seven holes, seven-eighths of an inch in diameter, were bored, through each of which a jagged bolt was passed, by which the several layers of timber were held together.

The basement of the tower consisted of two courses of solid oak, and upon these were laid five courses of Cornish moorstone, each one foot thick, the stone being held together by iron cramps without mortar or cement. The outer courses were further secured against the chance of their being lifted by the action of the sea by upright stones. Upon this 120 tons of moorstone were laid, and then two courses of timber, protected at their exposed extremities by horizontal timbers, scarfed together and bolted to the interior timbers. Up to this point the building was entirely solid. Upon this basement a well-hole was commenced to be left around the vertical mast 6 feet 9 inches square to contain the stairs, and at a point 8 feet above the highest part of the rock the step for the doorway was left. The building consisted of alternate layers of moorstone and timber up to the top of the central mast, and then a flooring of 3-inch oak plank was laid over the whole. The upper portion of the building comprised four rooms, one over the other, formed of upright timbers based upon and headed by a circle of timber to which their extremities were secured. The upright timbers were very securely connected together by tree-nails and bolts. The floor of the lantern was formed of 3-inch oak plank, and around this was the balcony.

The dimensions of the finished structure were as follows:—22 feet 8 inches diameter at bottom; 14 feet 3 inches diameter at top; the height from the circular base to the top 61 feet. The upright timbers which covered the entire exterior of the building varied in length from 10 to 20 feet, united at their extremities by scarfing and overlapping, care being taken that no two scarfs adjoined each other. The uprights were seventy-one in number, made of timber 9 inches thick at the base of the building, and 12 inches broad at the same part, but gradually diminishing towards the top in breadth and thickness. The outside seams between these uprights were caulked with oakum and pitched. The entire weight of stone employed in the building was estimated at 270 tons, and undoubtedly served as ballast in steadying the building. The doors and the shutters to the windows were composed of double plank crossed, and shut close in a rabbet to prevent the ingress of water.

That such a building should have withstood the tempest for fifty-five years is a proof of its strength, and, indeed, its career might have been much longer had it escaped destruction by fire, a calamity which happened to it in December, 1755. There can be no doubt that one of the chief errors in the construction of Rudyerd's lighthouse was the great quantity of timber employed in it, and its employment in such vital position as it occupied in the building.

The magnificent structure which was to follow will be described in our next chapter.

PHOTOGRAPHY.—IX.

By J. C. Leake.

DRY-PLATE PROCESSES: FOTHERGILL'S—COLLODIO-BROMIDE.

The collodio-albumen process described in our last article, while it may be considered as one of the most certain and reliable, is yet somewhat too complicated to become a favourite with those operators who have been used to the simple and rapid preparation of the ordinary wet collodion plates. In this article we therefore propose to describe the processes known as Fothergill's, as well as that which has received the title of collodio-bromide; both of which are more easily manipulated, and perhaps more sensitive than the collodio-albumen, although more delicate and not quite so certain in their action. The Fothergill process is one which will be found exceedingly useful to the photographer who may be constantly employing the ordinary wet collodion process, inasmuch as any good bromo-iodised collodion and the ordinary nitrate-of-silver bath will answer for the preparation of the plates, thus avoiding both the outlay and the trouble of keeping two separate sets of chemicals. The collodion for this process should not be too freshly iodised, as in practice it has been found that an old sample not only produces better results, but that the film adheres more closely to the glass during the various washings which the plate has to undergo. A sample containing a full amount of bromide should be selected, as tending to produce greater softness, as well as helping to secure cleanliness during the development. The only solution required beyond those employed in the wet collodion process will be one of diluted albumen, prepared as follows:—Pure albumen (from fresh eggs), four ounces; distilled water, four ounces; strong ammonia, twelve minims. Mix and thoroughly beat up, as described for the collodio-albumen process. This solution must be filtered before use. After exciting the plate in the usual manner, wash carefully in filtered rain-water, or, better still, in that which has been distilled, so as to remove the whole of the free nitrate of silver. Now immerse the plate in a bath, or flood it with the following solution:—Nitrate of silver, two grains; distilled water, one ounce. If this solution be poured over the plate, allow it to remain on some minutes. The albumen solution should then be poured over the film two or three times, and the plate washed very carefully with a moderate quantity of filtered rain-water. This final washing is of the utmost importance, as upon the proper performance of this much of the success of

the operation will depend. The object is to leave a sufficient trace of the albumen upon the surface of the plate, and consequently a measured quantity of water is used for this purpose, in order to ensure this result. It is difficult to state the exact quantity which should be employed for this purpose, as it seems to vary with the quality of collodion and other circumstances; but as an example, it will mostly be found that one pint will be sufficient for a plate of eight inches by six. After this washing, the back of the plates should be wiped dry with blotting-paper; and they may then be dried in a warm and dry box, of course most carefully preserved from light or dust. The average exposure will be from twice to three times that required for wet plates; and although these plates may be kept for some time both before and after exposure, by far the best results will be obtained by exposing as soon as possible after preparation, and developing within a short time after exposure. Nothing like the same latitude can be allowed in this as in the collodio-albumen process, and it could not be considered safe to keep these plates more than a fortnight before and a few days after the exposure to light in the camera. The plate after removal from the camera should be flooded with distilled water, to which has been added a small proportion of alcohol, and when the film has been thoroughly wetted the developer may be applied. For the process above described, the following will be a proper developing solution:—Pyrogallic acid, two grains; distilled water, one ounce; a few drops of alcohol may be added if required. In a few minutes the picture will begin to appear (if it should be unusually slow in development, a trace of nitrate of silver may be added to the solution), but it will be exceedingly thin. When all the details are developed wash off the solution, and proceed to intensify with the solution composed of pyrogallic and citric acids, as recommended for the ordinary wet collodion process; to which must be added nitrate-of-silver solution as required.

As we have before remarked, the intensity of negatives by dry processes must not be estimated so much by the actual density as by the colour of the deposit, and hence over-development must be most carefully avoided. In this, as in the collodio-albumen process, the hyposulphite-of-soda solution will be the proper fixing agent.

A somewhat important modification of this process has recently been introduced with considerable success by Dr. Ryley. In this the plate, after having been sensitised and thoroughly washed as before described, is coated with the following albumen solution:—Albumen, two ounces; water, four ounces; ammonia, one drachm. This solution to be well mixed as above described, and filtered before use. Allow this to thoroughly soak into the film, thoroughly wash the plate with distilled water, and dry. When perfectly dry moisten with distilled water, and cover with the following solution:—Gallic acid, four grains; distilled water, two ounces. Filter before use. Allow this solution to thoroughly soak into the film, and dry without washing off the gallic acid. Plates thus prepared will retain their sensitiveness for five or six months, and they are particularly clean and free from stains and markings. It is necessary, however, to be particularly careful to remove the whole of the nitrate of silver after the sensitising process. The development may be conducted precisely as in the ordinary Fothergill process before mentioned.

The next process of which we shall have to treat is one which will tax the care and manipulative skill of the operator to a considerable extent, and which should therefore not be attempted until he has acquired considerable experience in other and less delicate and complicated work. The process to which we refer is termed by its inventors, Messrs. Sayce and Bolton, the collodio-bromide; and one of its chief peculiarities is that it dispenses with the nitrate-of-silver bath common to all other methods of preparing a sensitive surface by means of a collodion film, the collodion in this case itself containing the sensitive salt. The collodion suitable for this process is composed as follows:—Pyroxyline (gun-cotton), six grains; ether and alcohol, of each, half an ounce; bromide of cadmium, six grains; bromide of ammonium, two grains. Dissolve the salts in the alcohol, mix with the ether, and add the pyroxyline, until dissolved. This collodion may be mixed in any quantity, as it will keep an indefinite time, but it should be allowed to stand at least a week before use. In order to render this collodion sensitive, nitrate of silver must be added to it in the proportion of from eleven to thirteen grains to the ounce of fluid; the smaller quantity being the safest, and the larger producing the most sensitive film. The nitrate of silver must be ground to the utmost degree of fineness in a glass mortar, and be added by degrees to the collodion in the proportions above given, with constant agitation, in order to ensure perfect combination. Of course this mixing must be effected in non-actinic light, as the compound is exceedingly sensitive to light; in fact, it must be treated precisely as a sensitised wet collodion film in this respect, the smallest ray of light being sufficient to spoil it. After resting a few hours the sensitive mixture will be ready for use. The plate may now be coated exactly as in the wet collodion process; although it may be at times advisable to coat the edges of the glass for about a quarter of an inch over their surface with a solution of india-rubber in benzole, in order to prevent the slipping of the film. When coated allow the collodion to become thoroughly set (much more so than in the ordinary wet process, when a bath is employed), and wash in a dish of water until the greasiness upon the surface disappears, and the water flows freely over the film. The plate will now be ready for the final immersion in a solution prepared as follows:—Dissolve in four ounces of hot water twelve grains of gallic acid, forty grains of tannin, and twenty grains of grape-sugar; and when cold one drachm of alcohol. This solution may be used almost indefinitely. Into this solution immerse the coated plate, and allow it to remain three or four minutes; upon removal drain thoroughly, and dry as in the ordinary process, when it will be ready for exposure in the camera. The time usually recommended for exposure is three times that required for a wet plate, but the writer has found that plates prepared with a full quantity of silver will not, under favourable conditions, require more than twice the exposure necessary for ordinary collodion work; and it should be remembered that the powerful developing agent proper for use with these plates will often enable the operator to bring out an image even when the exposure has been slightly shortened. The proper developing agent for collodio-bromide plates is one of comparatively recent introduction, and is known as the alkaline pyro-developer.

In the preparation of this developer it is advisable to make up stock solutions in three separate bottles, as follow:—No. 1 should consist of pyrogallic acid, one and a-half drachms; absolute alcohol, one ounce. No. 2, carbonate of ammonia, one and a-half drachms; water, one ounce. No. 3, bromide of potassium, ten grains; water, one ounce. When required for use, mix solution No. 1, ten minims; solution No. 3, five minims; water, one ounce; and pour them over the wetted plate. After remaining upon the surface about half a minute, pour this solution back into the developing-glass, and add four or five drops of the carbonate-of-ammonia solution, and apply the mixture to the plate again. In all probability the developing will commence almost instantly, and should it appear too rapid the action must be checked by the addition of a few drops more of the bromide solution. Should the development be tardy from under-exposure or other causes, more of the pyrogallic solution must be employed, leaving the bromide out altogether. With careful and judicious treatment, the development will not take much longer than is required for wet plates, but it is better to work slowly than to hurry the process in the least degree. It sometimes happens that plates develop well, but with little intensity. In this case it is better to wash off the alkaline developer, and complete the intensification with ordinary pyrogallic acid and silver, as in the wet process. It must here be explained that in the compound developer given above the chief reducing agent is the pyrogallic acid, the action of which is considerably intensified by the addition of the carbonate of ammonia. The bromide of potassium is simply a restraining agent, employed to keep the other chemicals in something like order; in fact, it plays the same part as acetic or citric acids in the ordinary processes, and the addition of too much of it will not only restrain the action of the pyrogallic acid, but altogether destroy it, and prevent any development from taking place. When sufficient density has been obtained, the plate may be fixed in the usual way; but it has been advised that cyanide of potassium be used instead of the hyposulphite of soda, on account of the latter causing an increased tendency on the part of the film to leave the glass upon which it is supported.

In concluding this part of our subject, we may here recapitulate some of the most important points which must be observed if the highest success be desired in dry-plate work. In the first place, the glass plates used must be of good quality, and most perfectly cleaned; in the wet process this is important, but much more so in the dry. In the former case the film in its sensitive condition is only in contact with the glass for a comparatively short period, while in the latter it may be for days or weeks. This, of course, gives full scope for any deleterious action which may be set up, and the result is dirty and spoiled plates, many failures, and much disappointment. Besides being quite clean, however, the plates should be perfectly dry, or there will be a greater tendency to splitting and tearing up of the film during the washings which it will have to undergo. When coating the plate, allow the collodion to become well set before immersion in the nitrate bath, or the same tendency will be manifested. Be sure to keep the nitrate bath up to its full strength, and always test it with a wet plate to ascertain that it is in good working order before preparing a batch of dry plates. Allow full exposure in the camera, as a little over-exposure can be remedied, but under-exposure never. Before proceeding to develop a plate, varnish the film about a quarter of an inch round the margin; this will prevent the water getting under it and breaking it up. Wash well after fixing, or the hyposulphite will destroy the negative; above all things, be careful in the water used for washing plates before exposure, as many failures may be traced to the employment of that which is impure. It is for this reason that we have advised the use of distilled water in many cases when ordinary water is usually recommended. Finally, the utmost care and cleanliness must be observed, especially in the dishes and vessels employed for washing the sensitive plates.

SEATS OF INDUSTRY.—XXVI.

NEWCASTLE-UPON-TYNE (*continued*).

BY WILLIAM WATT WEBSTER.

To continue our account of this town, within the past few years the making of fire-bricks has attained gigantic proportions, about eighty millions being manufactured yearly in the district; and gas retorts and sewage pipes are produced in large quantities, and sent to all parts of the world. Grindstones from the Newcastle quarries are made at the rate of about 100,000 per annum, and Portland and other cements are manufactured to the extent of some 11,000 tons. There are several large paper works of high reputation, and several large tanneries in the vicinity of Newcastle. Between five and six hundred dozen hats and caps are weekly produced in the hat factories of the town, which employ an aggregate of about 500 persons; and coach-building has in recent years become an important trade. Besides those we have enumerated, a large variety of minor industries are actively prosecuted in and about Newcastle. The trade of the port consists chiefly of coal, and articles for the manufacture of which coal is largely required. Including North Shields and South Shields, which may be considered sub-ports of Newcastle, more vessels are owned on the Tyne than belong to any single port in Great Britain, Liverpool and London excepted.

Newcastle is situated on the north bank of the Tyne, and is 9½ miles from its mouth, 54 miles east of Carlisle, 244 miles from London by road, and 275 by the Great Northern Railway. It stands partly on an elevated terrace, and partly on ground that slopes towards the river. The pits from which the coal is obtained lie within about two miles of the Tyne, and extend from within two miles of its mouth for sixteen or eighteen miles up the river. There are upwards of fifty large collieries at work within eight miles of the town. During the past fifty or sixty years very extensive improvements have been made in the streets and houses of Newcastle, and it is now one of the handsomest towns in England. Formerly a large proportion of the houses were constructed of timber, with the upper storeys projecting over the lower, and quaint gables and dormer windows, and at a later date they were built of brick; but all the modern streets are lined with houses of stone, which is found in abundance in the neighbourhood. It was principally through the exertions and public spirit of an enterprising citizen, named Richard Grainger, that this change was effected; but an extensive conflagration that took place in 1854 also indirectly contributed to the improvement of the town. Many of the streets, squares, and public edifices possess great architectural beauty, and the town is excellently lighted and paved. The water-supply, which is abundant and of good quality, is derived from streams and small rivers to the north-west of the town. The railway viaduct, or High Level Bridge of Newcastle, is one of the engineering triumphs of Robert Stephenson. This gigantic work is 1,337 feet in length, and its height above the water-mark is 112 feet. It consists of four river and two land arches of cast iron, supported on piers of masonry; and below the railway there is a carriage road for ordinary traffic 35 feet wide. The entire structure cost £491,153, and was opened by Queen Victoria in 1849. All the railways entering the town stop at a large station near its centre, and nearly seventy trains arrive and depart daily. The market for the sale of butchers' meat and vegetables, constructed by Robert Grainger, is 310 feet in length, has an area of 9,050 yards, is lined with 243 shops, besides stalls, and is entered by 14 doors. It is one of the most spacious and convenient public markets in the kingdom. A bi-weekly corn, and a weekly hay, produce, and cattle market are held in Newcastle, and both are of considerable commercial importance. During the year 1862, 54,936 fat cattle, 286,110 sheep and lambs, and 34,544 swine were sold in the cattle market. The Newcastle News Room is one of the finest in Great Britain; and the theatre, situated in Grey Street, the handsomest thoroughfare in the town, is an elegant building, designed after the Pantheon at Rome. There are thirteen churches and chapels connected with the Established Church in Newcastle, and about twenty-eight places of worship belonging to other denominations. The most ancient and interesting ecclesiastical edifices are the church of St. Nicholas—originally founded in 1091 by Osmond, Bishop of Salisbury, and placed under the jurisdiction of the Bishop of Carlisle—which was burned in 1210, the present structure having been finished in 1359; and St. Andrew's Church, said to have been built by David, King of Scotland, partly Norman in style, with a large but low embattled tower. Among the educational and literary institutions of the town, the most noteworthy are the Free Grammar School; the School of Medicine and Surgery, the lectures at which qualify for the diploma of the London College of Surgeons and the licence of the Apothecaries' Company; and the Literary and Philosophical Society, established in 1693, which occupies a handsome Doric building, and possesses a museum and a library. The principal monuments in Newcastle are a column, surmounted by a statue of Earl Grey, erected in commemoration of the passing of the Reform Bill of 1832; and a bronze statue of George Stephenson.

During the present century the population of Newcastle has increased at nearly the same rate as other English towns. In 1801 there were in the borough 28,366 inhabitants; in 1811 the number declined to 27,587; in 1821 it rose to 35,181; in 1831 it was 42,760; in 1841, 69,430; in 1851, 87,784; in 1861, 109,108; and in 1871, 128,164. Although in a different county, and under a separate jurisdiction, Gateshead, on the opposite bank of the Tyne, must be considered as a suburb of Newcastle. The population of Gateshead ought, therefore, to be added to that of Newcastle, and in 1851 there were in Gateshead 25,568 inhabitants, making a total population for Newcastle, plus Gateshead, in that year of 113,352. In 1861 the population of Gateshead was 33,587, which, with the population of Newcastle, makes a total of 142,695; and in 1871 it was 48,592, giving in the same way an aggregate population of 176,756. The electoral limits of Newcastle were enlarged under the Boundary Act so as to include, with the old borough, the townships of Jesmond, Heaton, Byker, Elswick, and Westgate. Newcastle was divided by the Municipal Act into 7 wards, and is governed by a mayor, 13 other aldermen, and 42 councillors, and has a commission of the peace under a recorder. The town has the privileges of a county, and it is represented in the House of Commons by two members. Among the eminent natives of Newcastle are numbered Duns Scotus; Mark Akenside, the poet; Hutton, the mathematician; Lord Eldon, the celebrated Lord Chancellor; his hardly less celebrated brother, Lord Stowell; and Admiral Collingwood. Intimately connected with the town, though not born there, were Thomas Bewick, the famous wood engraver; Robert Morrison, the Chinese scholar; and George and Robert Stephenson, the engineers.

SANITARY ENGINEERING—XIX.

CLOSETS AND TRAPS.

In our last paper we gave some detailed information as to the saving of water by means of flushing cisterns, and also alluded to the necessity of providing ventilation for systems of pipes. We now approach a branch of the subject which, although it may not be considered pleasant by the general reader, is perhaps, considered from a strictly sanitary point of view, superior in importance to any that have preceded it, as we now come in contact for the first time with a matter which has recently occupied no small share of public attention—namely, sewage gases; and before entering upon the mechanical details, it may be as well to show to a certain extent the nature of the dangers to be apprehended and the difficulties to be overcome.

Sanitary engineering, as far as this particular branch of it is concerned, may be dated as commencing within a century. Previous to that date the old cesspool system was almost alone in operation, and although probably, or indeed certainly, the various complaints arising from imperfect hygiene were as widely spread and as deadly in their effects, public scientific attention had not been awakened, and the information now at our command was not available. And here let us note that it is by no means the most offensive gases that are the most deadly. As an extreme instance, we may quote a case which occurred in the western part of London some years ago, when on entering a large section of a public sewer which had been hermetically closed for some time and out of use, and through which no current either of water or air had passed, some of the party were actually and instantly stifled by the deadly vapour. Others who escaped with difficulty described the only warning of danger they received as something like a faint smell of rotten cheese.

Again, in another form, in a house recently erected in the north of London, three successive families who occupied it lost almost immediately several of their members by typhoid fever, although there was no such distinct intimation of the presence of defective drainage arrangements at any time as would be sufficient to attract attention. This we may take for granted, as otherwise the house would not have been entered by fresh tenants at comparatively short intervals of time without some investigation being made. Ultimately the case was taken up by the local sanitary authorities, when it was discovered that beneath the surface of the basement was a bed of partially decayed vegetable and sewage matter, from which this sewer poison arose, though its presence was not so patent as to be detected by any ordinary occupant. Quoting from a pamphlet by Dr. Alfred Carpenter on this subject, he says:—"It was not until the general introduction into towns of closets and pipe-sewers that the injury produced by the gas was sufficiently isolated to be positively identified. The result of the introduction of closets within the walls of our houses casts a reflection which is not altogether deserved, and which need not necessarily be borne. This mischief has arisen from a neglect of a natural law—viz., not providing for exits as well as for entrance, sewers not being, like soda-water bottles, sufficiently impermeable as to allow of being charged with gas under pressure."

In succeeding practical illustrations we shall more than once have occasion to refer to this axiom, as we may term it. In the early sanitary works which were carried out under the authority of the Public Health Act of 1848, the consequences of sewer gas not being foreseen, were not provided against. No provisions were made to prevent its ascent into the house or exit into the open air before it could reach the inside of the dwelling. "As a factor in the production of typhoid fever its power is now well known; many other disorders of the system have been directly traced to its influence, diarrhœa, dyspepsia in all its forms, various forms of asthma, and headaches constant and intermittent."

The same author also quotes a very telling case of ill-considered trapping. When the Warehousemen and Clerks' Schools at Russell Hill were first opened the children were in the enjoyment of good health, but in the autumn of 1867 typhoid fever made its appearance. It seems that a smell at first slight, but afterwards intense, had been perceived in the laundry. The place of exit was trapped, and the smell prevented at that place from the sewage gas until it reached the interior of the building. The consequence was that it was conveyed from the cesspool by the pipe-sewers into the lower part of the building, and then into the other rooms. The arrangements for general ventilation being deficient, and many of the rooms heated by hot water, so that there were no open fires, an accumulation of sewer gas frequently took place during the night, and the children entering the rooms before breakfast were exposed to its influence under the most unfavourable circumstances, the result being that 40 per cent. suffered from forms of typhoid fever, which was, however, fortunately of a mild type.

Instances might be multiplied almost indefinitely showing the deleterious effects of sewer gas. The last two we have quoted show how in positions where such a result might be considered quite unexpected, its evils were experienced, and we must leave untouched the vast question connected with the crowded dwellings of the poorer classes, where in many parts of London and our larger provincial towns, sanitary arrangements, though much improved of late years, are still lamentably defective.

Having thus briefly indicated the direction in which precautions have to be taken, we now proceed to the mechanical part of the question, merely premising that each example selected is only one of a class. The number of appliances patented within the last twenty years may probably be reckoned by hundreds, some entirely novel, some merely adaptations; and we commence with the general statement that in all closets treated in the present paper the water-lute or hydraulic seal is the principle adopted. With earth-closets and other methods of sewage disposal, in which different methods are employed, we propose to deal at length in future articles. The general principle of the water-lute is that a body of water shall always be maintained at the topmost part of any system of sewage delivery, so that no free air-passage for gas is left open. The simplest form for illustration of the principle is the old-fashioned brick trap with a dipstone, as in Fig. 14, applied in an ordinary drain.

We give this illustration at this point to show the simplest possible arrangement for the passage of sewage and water and the exclusion of air in the course of an ordinary drain, assisted by flushing, and the necessary currents to which drains should always be laid. It will be seen that the "dipstone" has its lower edge always in the water, thus stopping all passage of air; but there is this remark to be made, that a "*double trap*," as it is technically called, is invariably a source of failure and discomfort. Supposing by some blunder two of these traps constructed in one drain within a few feet of each other, the gas contained in the intermediate portion of the drain immediately becomes "water-bound," and instead of passing away through the second trap, this acts as a check upon the air or gas, whichever may happen to fill the space, and although the sewage or water may run off, the gas confined between the two traps, instead of passing off through the *second*, will bubble up through the *first*, unless (and here we may refer to our last paper on the ventilation of pipes) an *exit* to the external air is provided, either in the shape of an air-pipe or by some other means. We give this illustration in the plainest form, as it embodies the one leading principle of all closets or traps where water is used, however complicated in their appliances or expensive in their fittings—to provide an efficient hydraulic lute or water-seal, and avoid all chance of "*back* pressure," whether arising from double-trapping or tidal influences, a most important point for consideration in low-lying districts, such as Bermondsey, or waterside localities, such as Scarborough.

The plain general principle thus stated, we arrive at the first portion of the subject proper of our paper, "Closets," and proceed to give a few illustrations of the appliances now in general use, with a few words of explanation as to each. The great improvements in what may be called sanitary pottery have placed us very far in advance of the last generation in this respect. Our first (Fig. 15) is a plain cottage trap, dependent upon simple flushing, without any mechanical contrivances. This is made of plain earthenware.

Our next illustrations (Figs. 16, 17) show the action of one of the most recent improvements in earthenware. It will be seen that the valve, closet, and trap are manufactured in one piece of earthenware. The manufacturer is Mr. George Jennings, of Lambeth.

We now pass to various descriptions of closets where the basin only is in china and earthenware, and other portions of fittings in metal. Fig. 18 is what is ordinarily described as a *pan* closet. Within the receiver A (Fig. 18) is contained the hinged pan B (Fig. 19), and the water-line, when shut, is indicated as before.

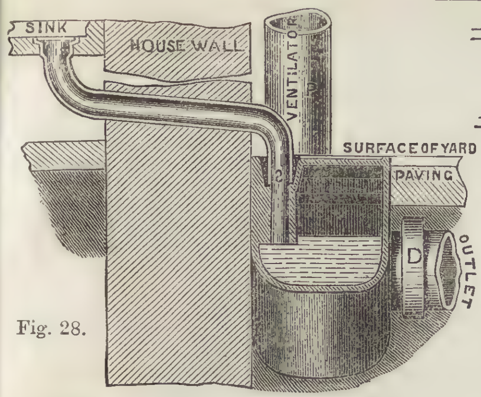


Fig. 28.

Fig. 29.

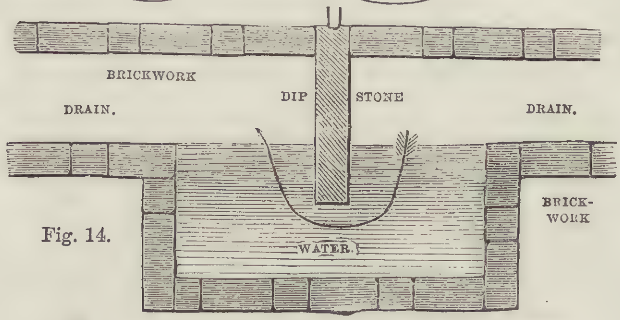


Fig. 14.

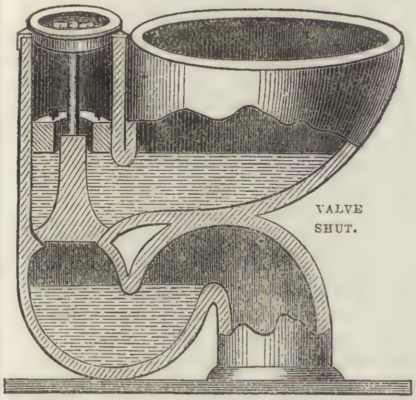


Fig. 16.

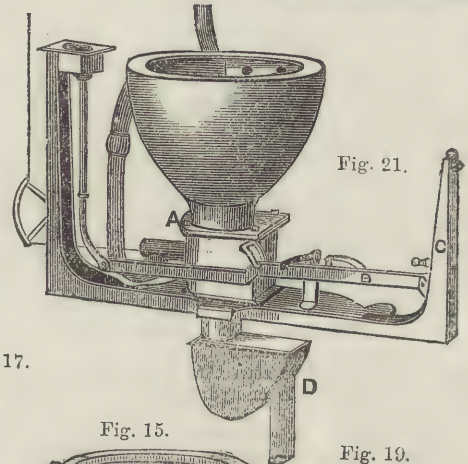


Fig. 21.

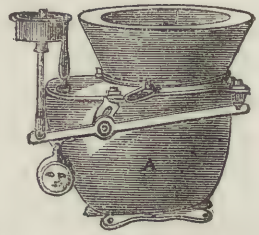


Fig. 18.

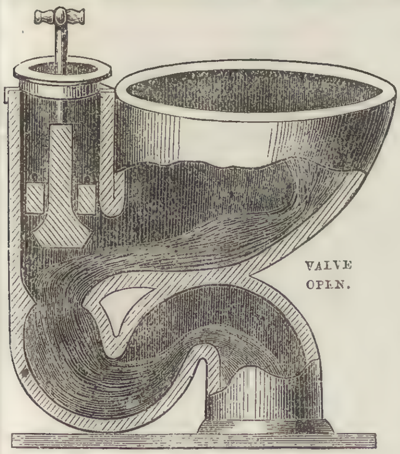


Fig. 17.

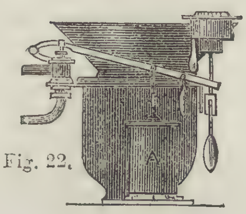
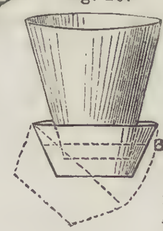


Fig. 22.

Fig. 15.

Fig. 19.



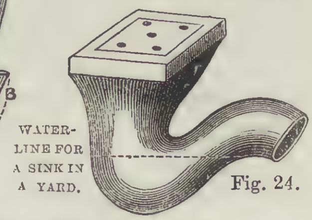


Fig. 24.

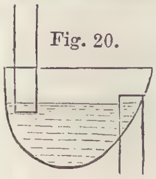


Fig. 20.

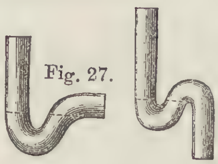


Fig. 27.

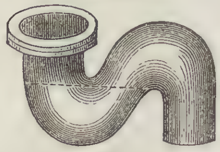


Fig. 25.

SHOWING WATER-LINE FOR VERTICAL PIPE.

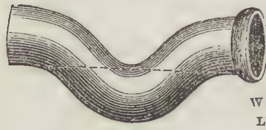


Fig. 23.

SHOWING WATER-LINE FOR HORIZONTAL PIPE.

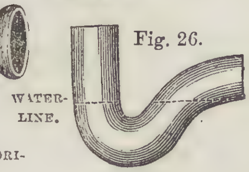


Fig. 26.

Valve closets are differently constructed. Here (Fig. 21) the water-line is maintained by a valve at the bottom of the basin, carefully ground in or maintained in its place, or hermetically sealed by a lever and spring. The valve is at A, B is the lever, and C is the spring. In this case the additional security of what is technically called a D-trap is shown at D; this is made of lead, and its internal construction and water-line are shown in the outline sketch in Fig. 20.

Fig. 22 shows a closet known as Underhay's Patent, which provides a bellows arrangement for the gradual delivery of the water, indicated at A. These closets are often provided with elastic or india-rubber valves, and there are many mechanical details of construction introduced, upon which a volume might be written; but with this last instance we dismiss the question of closets, and proceed to that of traps, of which we shall also give some sketches, showing two or three of the most important improvements recently introduced.

We have now passed the points of construction at which

water-supply and ventilation only are to be dealt with, and have arrived at that period in our papers on "Sanitary Engineering" at which it is to be taken for granted that all air to be dealt with is *foul*, that is to say, charged in a greater or less degree with sewage gases; and the *raison d'être* of *traps*, is to provide a vessel through which, in whatever form it may be constructed, sewage elements may pass if contained in a volume of water, without allowing any air to return by the passage. And here arises a question as to the comparative *size* of pipes and drains. When the subject was, as we may say, in its infancy and little understood, the idea was started that by having the minimum size both of pipe and drain, sewage elements could be forced downwards with their attendant gases, and the whole bodily discharged into the ultimate receptacle, whatever that might be; and at that time it was not uncommon to hear of conveying the whole drainage of a household through a 3-inch pipe. The error in the first place was in the theory, as these gases can never be forced downwards, the effect of any pressure slightly exceeding that of the ordinary atmosphere being sufficient to return them through all the ordinary traps and water-lutes, and to raise them to the surface in bubbles; and in the second place, mechanical, as the accompaniments of ordinary kitchen washings, sewage being left out of the question, were sufficient, by their gradual accumulation of solid matter, grease, or otherwise, to create an absolute stoppage. We quote from a well-known publication :—" In the 'Menzies' system it is supposed that by having pipes only of sufficient size to carry the sewage matter, gases will have no room to form, or be forced downwards. Unfortunately the facts are otherwise. For the pipes often choke at Aldershot, where this system is in operation, and the *matter* (*sic*) bubbles up, entailing a cost of several hundred pounds annually to open and repair them, in effecting which it is impossible to avoid danger from letting loose some of the gas."

A pipe of ample size, well flushed and thoroughly ventilated, has been proved by experience to be the only efficient medium for removing sewage. Into the detail, construction, and manufacture of the various descriptions of pipes we do not here enter, as under another heading in the series of THE TECHNICAL EDUCATOR these questions will be dealt with at length. We content ourselves with giving a few sketches (Figs. 23, 24, 25), showing the various methods of trapping stoneware drains, marking the water-line in each case. It will be seen that in every case the only protection is the water-lute or hydraulic seal to prevent the passage of foul air.

The D-trap, of which an outline sketch is given in Fig. 20, and which in a slightly modified form is also called a P-trap, was for many years the only form of trap available in plumbers' work. Where size is required, it is made of pieces of lead soldered together, into which the inlet and outlet pipes are secured by similar means. A new form of trap has, however, been introduced within the last few years by Messrs. Beard and Dent, and is the subject of a patent. The trap can be cast in one piece of lead to any size, as may be seen in the sketch, and presents many advantages. There is much less room for the accumulation of sediment, offensive or otherwise, and the absence of joints is a great safeguard against leakage or failure from any similar cause. We subjoin two sketches (Figs. 26, 27) showing the form of trap and the water-line. It will be seen that though the material is different, the principle is identical.

The difficulty overcome, and therefore the secret discovered and made the subject of the patent, was the removal of what is technically called in casting the "core," *i.e.*, the inside of the mould; an ingenious mathematical combination of pieces which we can only compare to a puzzle, and which no diagram could make intelligible, attains the desired effect. The same firm have applied these traps to closets, with various improved valves, india-rubber and otherwise; but having already given some general ideas of that subject, we have no space for further detail.

The last modern improvement is the introduction of ventilating traps, which, while they intercept the passage upwards of foul air from the drains, provide also for its dispersion to the external air *outside* the walls of the house.

We give a section of one, Mansergh's patent (Fig. 28), applied to a sink only, but it will be readily seen how it is also applicable to the *release* of foul air from any system of drainage. Another recently introduced is the invention of Mr. Cottam, an Associate of the Institution of Civil Engineers. It consists of what may be called a twofold trap (Fig. 29), with an exit to the open air in the centre, provided with a body of charcoal as a disinfectant to the gas involved. In giving this we are to a certain extent touching upon the subject of subsequent papers—the disinfection of sewage gases; but as perhaps the most novel effluvium interceptor, as it is termed, which has been introduced, we conclude at this point the subject of closets and traps, one of the most important (as will appear from the cases cited at the commencement of this paper) of all that fall within the province of the engineer.

BUILDERS' QUANTITIES AND MEASUREMENTS.—X.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY (*continued*).

IN the last lesson we explained at length the methods adopted in measuring the various works which are executed by the joiner in the erection and finishing of buildings. We now proceed to show by examples how those rules are to be put into practice by the measuring surveyor, either in taking out quantities from plans, or in measuring work actually executed. In practice it is advisable to enter the works on each floor separately in the dimension book, so that they can more readily be referred to afterwards, if any question should arise as to the correctness of the measurements. The measurer is also less likely to miss any part of the work by completing each floor before he proceeds to the next. The staircases may be left to the last, unless they differ at each flight, when they may be taken at the same time as the work on the floor to which they belong is measured.

TWO-PAIR FLOOR.

15 0 12 6	187 6	2 cut w. batten folding floor.
2) 4 6 0 9	6 9	Add recesses.
6 6 3 6	22 9	Add landing.
	217 0	
44 0 0 7	25 8	1 in. sqre. skirting.
3 6 4 6	15 9	Dl. cased frame, o. sk. sill, $1\frac{1}{2}$ in. ov. sash, dble. hg., br. pulleys, white lines, i. wts.
	No. 1 brass sash fastening.	
13 6 0 5	5 8	$\frac{3}{4}$ in. framed grounds.
14 0	14 0	1 in. archve. mo., $2\frac{1}{4}''$ wide.
4 6	4 6	1 in. window nosing.
6 6 2 9	17 11	$1\frac{1}{2}$ in. deal square 4 p. door.
	No. 1 pair 3 in. b. and s. ,, 1 2-bolt i. rim lock, and b. furn.	
15 2 0 5	6 4	$1\frac{1}{2}$ in rebd. and bdd. linings.
16 0 0 5	6 8	$\frac{3}{4}$ in. frad. grounds.

2)	16 6	33 0	1 in. arch. mo., 2¼ w.
	7 0 4 6	31 6	1¼ in. framed closet front.
	6 0 2 9	16 6	Ddct. door.
		15 0	
	6 0 2 9	16 6	1½ in. 2 p. square door.

No. 1 pr. 2½ in. b. and s. 1 brass knob turnbuckle.

	4 6 1 3	5 8	1 in. closet top, w. 2 sides.
	4 6	4 6	1 in. arch. mo., 2¼ w.
	4 6	4 6	1 in. dble. bdd. pin-rail.

No. 6 japd. cloak pins and screws.

	4 0 0 9	3 0	1¼ in. shelf.

No. 2 rod. corners to 1¼" shelf.

	20 0	20 0	Sqre. angle staff, plugged.

STAIRCASE FROM ONE-PAIR TO TWO-PAIR.

	22 0 3 0	66 0	1¼ in. dl. treads, 1 in. risers, glued and blocked to close string, moulded nosings, 2 fir carriages.
	6 0	6 0	Nosing to 1¼ in. floor.
	3 0 0 9	2 3	¾ in. beadd. apron lining.
	3 6 5 6	19 3	Add winders.
	13 0 0 11	11 11	1½ in. reb. and bdd. close string.
	20 0 1 0	20 0	1¼ in. wall string, plugged.
	7 0 1 0	7 0	Add ramp.

No. 30 housings to flyers. 3 housings to winders.
,, 15 square bar balusters.

	13 0	13 0	2½ in. deal mldd. handrail.

No. 15 housings in handrail for balusters.

	15 6	15 6	2½ in. dl. turned newell.

No. 2 turned pendants to newell. 2 iron screw bolts.
,, 3 housings of winders into newell.

ONE-PAIR FLOOR.

	15 0 12 2	182 6	1¼ in. yell. batt., strt. jt. floor.
2)	4 6 0 9	6 9	Add recess.
	4 2 0 5	1 9	Add ditto.
	3 0 0 5	1 3	Add.
		192 3	
	3 6 1 6	5 3	Ddct. hearth.
		187 0	
	13 0	13 0	1½ in. mitred border to hearth.
	40 6 0 9	30 5	1 in. torus skirting.

No. 8 mitred angles to 1 in. torus skirting.

	40 6	40 6	¾ in. skirting grounds, plugged.
	7 0 0 7	4 1	1 in. sqre. skirting.
	5 0 7 0	35 0	1¼ in. bdd. closet front.
	6 0 2 9	16 6	Ddct. door.
		18 6	
	6 0 2 9	16 6	1½ in. mo. and sqre. 4 pl. closet door.

No. 1 pr. 2½ in. b. and s. 1 cupbd. lock. 1 brass knob turnbuckle.

	4 0 1 6	6 0	1 in. w. b. s. closet top.

No. 1 rod. corner to closet top.

	5 0	5 0	1 in. arch mo., 3½ in. w.
3)	4 0 1 3	15 0	1 in. w. b. s. shelf.

No. 3 rod. corners to 1 in. shelf.

	5 6 4 0	22 0	Dl. cased frame, o. sk. and weathd. sill, 2 in. lamb's-tongue sashes, dble. hg., b. pulleys, patent lines, i. wts.

No. 1 brass sash fastng. 2 ogee cut ends to stiles of sash.

	20 0 0 5	8 4	¾ in. rebd. and bdd. linings.
	21 0 0 5	8 9	1 in. rebd. grounds.
	21 6	21 6	1 in. arch. mo., 3½ in. w.
	3 6 2 3	7 11	1 in. mo. 1 pl. window back.
	3 6	3 6	¾ in. bd. at top of w. bk.
	6 6 3 0	19 6	2 in. deal mo. b. s. 4 pl. door.

No. 1 pr. 3½ in. b. and s., 1 6 in. ⅝ in. 2 bolt mortise lock, china furniture.

	15 6 0 5	6 6	1½ in. dbl. rebd. and bbd. linings.

No. 3 dvtl. blockings.

2)	16 3 0 5	13 7	1 in. framed and reb. ground.
2)	17 0	34 0	1 in. arch mo., $3\frac{1}{2}$ in. w.
	23 0	23 0	Sqre. angle staff, plugged.

STAIRCASE FROM GROUND TO ONE-PAIR FLOOR.

	21 6 3 3	69 11	$1\frac{1}{4}$ in. yell. dl. treads, 1 in. risers, mitred to cut-string, glued and blocked, moulded nosings, 2 fir carriages.
	3 3 5 6	17 11	Add winders.

No. 15 returned mo. nosings. 15 cut brackets.
,, 1 curtail scroll end. 30 dvtl. housings for balusters.
,, 15 housings for steps and risers. 3 housings for winders.

15)	3 3	48 9	Grooving and tongueing treads and risers.
	15 0 0 11	13 9	$1\frac{1}{2}$ in. reb. bdd. outer string, cut and mitred to riser.
	1 6	1 6	Add writhe, glued upright, reb. and bdd.
	15 0 1 0	15 0	$1\frac{1}{4}$ in. wall string, plugged.
	12 0 1 0	12 0	Ditto ramped.

No. 2 tongued angles to string. 18 housings.
,, 30 $1\frac{1}{2}$ in. turned balusters.

	15 0	15 0	3 in. moulded and Fr. pold. mahogany handrail.
	3 0	3 0	Writhe to ditto.

No. 3 handrail screws. 1 housing to newell.
,, 1 curtail scroll to handrail. 1 c. i. newell.
,, 30 housings in handrail for balusters. 1 screw nut and joint to cap.

	6 6 3 6	22 9	$1\frac{1}{4}$ in. mo. and sqre. spandril framing.

No. 1 pr. $2\frac{1}{2}$ in. b. and s. 1 cupbd. lock. 1 brass knob turnbuckle.

	6 6 1 2	7 7	$1\frac{1}{4}$ in. shelf.
	7 8	7 8	$\frac{3}{4}$ in. chamfd. fillet, $2\frac{1}{4}$ in. wide.

No. 2 c. i. brackets and screws.

MINING AND QUARRYING.—XXII.

BY GEORGE GLADSTONE, F.C.S.

BRASS.

CONSTITUENTS — MODERN PROCESS OF MANUFACTURE — ANCIENT PROCESS — YELLOW METAL — PROPERTIES OF BRASS — LACQUERING — ACTION OF ACIDS.

BRASS is an alloy of copper and zinc, in various relative proportions, but the ordinary composition is about 70 per cent. of the former to 30 of the latter. If more zinc be added, the alloy will lose in tenacity; and all the compounds in which there is an absolute excess of zinc are so brittle as to be practically valueless. The ordinary commercial article will often be found to contain some small quantity of lead and tin, but these are generally accidental impurities, often arising from the melting down of old metal to which some solder may be adhering.

The simplest plan of making brass consists in the direct combination of the two metals when brought to a molten state; but even in this some precautions are necessary in order to produce a satisfactory result. The process may either be conducted on the hearth of a reverberatory furnace or in crucibles placed in a kiln. The principal objection to the former is the risk of great loss in the weight of the product from the readiness with which the zinc oxidises and becomes volatilised.

The crucibles used are made of refractory clay; in these a certain quantity of pure copper is placed, and heated up to just the melting-point, when small pieces of metallic zinc are gradually dropped in and allowed to mingle with the other until a suitable proportion has been arrived at. This point will, of course, be determined according to the kind of brass wanted; but in any case the quantity of zinc used will have to be somewhat in excess of that desired to remain in the alloy, as, under the most careful management, 24 lb. of copper and 12 lb. of zinc will only produce $34\frac{7}{8}$ lb. of brass, having the per-centage composition of 68·8 of copper and 31·2 of zinc, showing that the loss is exclusively in the latter metal. Under the repeated re-meltings to which it may be subject in after use, the brass will continue to suffer some further loss in weight, and the relative proportion of copper will be found to be still on the increase.

As soon as the contents of the crucible have properly combined, the metal may at once be poured into sand moulds to make castings; but if it is intended merely to produce ingots of brass, for subsequent rolling or re-melting, closed iron moulds are used, which are gently heated prior to the alloy being poured in. The interior surface of the moulds is previously oiled, and dusted over with a little charcoal powder, to prevent the metals from adhering together.

The original process, but which is now rapidly going out of use, on account of being more tedious and expensive, though it is supposed by some to yield an article possessing superior properties, consisted in exposing the copper in crucibles to the action of a mixture of calamine or blende with charcoal. Calamine and blende are the two ores of zinc of most common occurrence in nature, and by this process of cementation the metal is separated from the carbonate and sulphide with which it is associated in the ore, and unites immediately with the copper without ever existing in a free state.

The arrangement of the furnace used in this manufacture is shown in Figs. 1 and 2, the latter being the horizontal plan at the level, A B, of one of the bed-plates of the kilns, C, D. The air is admitted through E, the open chamber below, and it thence passes up through the perforations (shown in Fig. 2) in the bed-plate, the current being increased by a flue which passes from F F into the chimney G, and which can be regulated by means of a damper as needs may require. On the bed-plate the crucibles H, H, etc., are so placed as not to interfere with the air-holes, and the space between them is loosely filled with coke, care being taken not to choke the draught. Each crucible will hold about 100 lb. of finished metal, but the weight of the ingredients which constitute the charge will be about 140 lb. The proportions of course vary according to the kind of brass to be produced, but the weight of calamine is usually in excess of that of the metallic copper, and the quantity of charcoal about one-fifth of the latter. The copper is always used in a granulated state, so as to present as large a surface as possible to the action of the other ingredients; and the calamine or blende is first calcined and finely powdered. If a brass is wanted which shall contain a large proportion of zinc, old brass is often used in part substitution of the copper. The crucibles are covered over, and the lids luted closely down, and they are kept up for some hours at a white heat; but the contents are not allowed to rise to a temperature at which the copper would melt, because in that case the liquid copper would all collect together at the bottom of the crucible, and only the upper surface would be exposed to the action of the zinc ores. After a time some white fumes of volatilised zinc will be found to escape from the stacks in the luting, which indicate that the process of conversion has so far progressed that the temperature may now be gradually reduced. The crucibles are then removed from the kiln, and opened; the dross is skimmed off the surface, and the contents then poured at once into the moulds.

Brass, under the name of yellow metal, is very largely used for the sheathing of ships, in lieu of copper; and as these sheets have to be manufactured upon a very great scale, it is not found to be practically convenient to make it by either of the processes already described. The most approved propor-

tions for this alloy are two-fifths of zinc to three-fifths of copper, and any variation from this should rather be towards an increase of the former than of the latter metal. It does not withstand the action of the sea-water nearly so long as pure copper, but the difference in the first cost is so great as to make it the more economical for the sheathing of ships; and the gentle action to which it is constantly subject from the sea-water always maintains a bright clean surface. It is usually made in reverberatory furnaces, the copper being first reduced to a molten state; and then the zinc is gradually added. A considerable amount of oxidation necessarily takes place in this kind of furnace, and under the most careful management the loss of zinc from this cause will be so uncertain as to render it necessary to test the metal before running it out into the moulds; in practice, moreover, it is rare that the pure metals alone are used, for the old metal which is stripped from the ships' bottoms at each re-sheathing (which occurs usually about every three years) is taken back by the manufacturer and re-melted, so that further elements of uncertainty are introduced into the operation. It is usual, therefore, to draw a proof of the alloy from the furnace, just as in the refining of copper, and test the sample ingot by passing it through the rolls, and then breaking it to see the character of the fracture. This is repeated till a satisfactory specimen is obtained, when it is at once run out into iron moulds, as we have already described. The ingots are rolled out into sheets while hot, then annealed, and finally cleaned by immersion in weak sulphuric acid, and a scouring with sand and water.

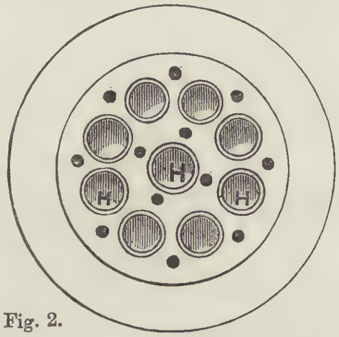


Fig. 2.

The physical properties of brass bear a strong general resemblance to those of copper; but it possesses certain advantages over the pure metal. The first of these is an economical one, the price of zinc being so very much lower than the other, that after allowing for the expense of manufacture, the cost of the product is very much lower than that of copper. The alloy is harder than either of its constituents, and is of greater density than their mean; but it melts at a lower temperature than copper, and produces very good and sharp castings, all which circumstances combine to render it a most suitable material for small engineering work. Moreover, it is less affected by atmospheric influences than copper, and by a very simple process which will be referred to presently, a most brilliant surface can be given to it which will effectually prevent it from tarnishing.

Hence it is applied to an almost infinity of uses, domestic, engineering, and scientific. It is constantly to be met with in locks, hinges, handles, buckles, and bolts; in ornaments for the table or mantelpiece; in chandeliers and gas-burners; in weights and scales; in the finer parts of nearly all steam-engines and other machines; in clocks; in mathematical and optical instruments, etc.

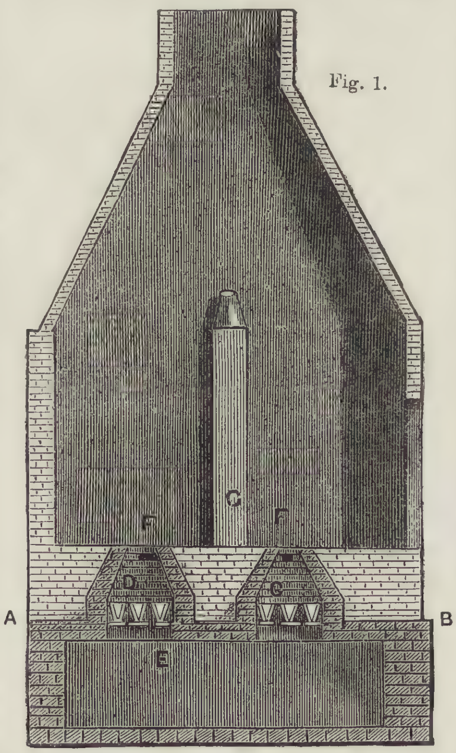


Fig. 1.

Brass is also highly tenacious, so that it can be rolled or beaten out into very thin sheets, and drawn into very fine wire. It can, indeed, be beaten out into leaf, quite as thin if not thinner than that of gold, for which it is often used as a substitute.

All these different qualities are of course more or less affected by the relative proportions of the respective ingredients; the table at the end of this article will serve to show roughly which are the most appropriate combinations for the various purposes that may be required. It should be borne in mind that the two metals will combine in any proportion; and the general character of any intermediate combination may be very fairly judged of by comparing the two given in the table between which it would take its place. As more zinc is added the alloy becomes still more brittle, it loses its fine colour, which then passes into a grey, and has no special quality to recommend it.

A slight admixture of lead, not exceeding about $2\frac{1}{2}$ per cent., is rather an advantage if the brass is intended to be worked upon the lathe, and a similar quantity of tin will not injuriously affect it when employed in making castings, while it is even advantageous if the brass is to be used by the engraver; but a much less proportion of either of these metals, or of antimony, will destroy its value for wire-drawing. For this last purpose the alloy cannot be too pure. A little antimony will in like manner affect the rolling of it into thin sheets by rendering the metal brittle.

Brass resembles copper in its behaviour under the hammer, and needs annealing from time to time in order to restore its malleability. During these repeated heatings the surface becomes tarnished by the formation of oxide, from which it is subsequently purified by dipping it into weak acid, and then washing it with water.

On prolonged exposure to the action of the atmosphere it gradually acquires a dirty black colour, but this can be effectually prevented by coating the surface when quite pure and bright with a thin film of lacquer. This is made by dissolving shellac in alcohol, and applying the solution to the surface by means of a fine brush. Both the articles to be lacquered, and the lacquer itself, should be thoroughly warm; and then, on drying, the thin film of lac will be found to be quite transparent, and to have so smooth and bright a surface as to resemble the most highly-polished metal. The lacquer adheres with such pertinacity to the surface that it can only be scraped off with difficulty, and the brass may afterwards be bent to and fro as much as one pleases without its being separated. By discolouring the surface of the metal, through the agency of acids or otherwise, prior to lacquering, various tints, such as those of bronze, can be produced; or a deeper tint may be given to the lacquer itself by the addition of some of the more highly-coloured resins.

If a dull or frosted surface is desired, which often forms an agreeable contrast to the other in ornamental work, it is produced by a process which is termed "dead dipping." In this case the brass is exposed for some time to a comparatively strong solution of nitric acid until the surface has become thoroughly granulated. It is then washed in pure water to remove all the acid, and next dipped in a cold weak solution of tartrate of potash, after which it is dried by rubbing it with hot sawdust. It is then ready for the application of the lacquer.

The action of acids upon various kinds of brass is not a little remarkable and instructive: for instance, a strong nitric acid will dissolve equal quantities of copper and zinc in an alloy in which the two metals exist in equal proportion, while a weak acid will especially attack the zinc and very slightly affect the copper. Indeed, if the alloy contains an excess of zinc the action of a weak acid will be much greater than if the two metals were treated separately; while if the zinc is only equal to or less than the copper, the alloy is only very slightly acted upon at all. Strong hydrochloric acid will dissolve out nearly

all the zinc from an alloy consisting of equal parts of each metal, leaving the copper almost untouched. A weak hydrochloric acid will dissolve out a portion of the zinc, provided this metal is in excess; but it has no effect whatever upon an alloy of equal parts of the two metals, or of any combination in which the excess is on the side of the copper. Again, with the strongest sulphuric acid, if the zinc is in excess, zinc only is dissolved, and that sparingly; but if the two metals are in equal proportion a greatly increased action takes place, and both metals are equally attacked by the acid. A weaker acid, having the formula $H_2SO_4 + 2H_2O$, scarcely affects any of the alloys containing an excess of copper; and that consisting of equal parts of the two metals is absolutely unaffected by it.

TABLE SHOWING APPROPRIATE COMBINATIONS OF COPPER AND ZINC FOR BRASS.

COPPER.	ZINC.	COLOUR.	OTHER CHARACTERISTICS.
PER CENT.	PER CENT.		
85	15	Yellowish red.	A very hard fibrous metal, with good working qualities.
80	20	Reddish yellow.	Rolls and hammers well. Good for wire-drawing.
75	25	Brass yellow.	Good working qualities. Highly tenacious. Used in machinery.
70	30	Brass yellow.	Common brass. Works well under the hammer.
65	35	Full yellow.	Rolls and hammers well. Good for wire-drawing.
60	40	Yellow.	Used for sheathing ships. Rolls moderately well.
50	50	Golden yellow.	Very fine colour; suitable for ornamental castings, but too brittle for other purposes.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVII.—THOMAS TELFORD, ENGINEER.

BY JAMES GRANT.

THOMAS TELFORD, one of the most distinguished of our civil engineers, was born in 1757, of humble parents, in the secluded and pastoral valley of Eskdale, as the eastern portion of Dumfriesshire is designated. At the parish school of Westerkirk, he received the education which generally falls to the lot of Scottish children of his class, and was sufficiently well grounded as to make himself master of Latin, French, and German. At the age of fourteen years he left school, and was bound apprentice to a jobbing builder in his native parish, and there he worked for some years as a stonemason. At the expiry of his time he proceeded to Edinburgh, where a new town was then in the course of erection, and studied the principles of architecture, till 1782, when he proceeded to London, where his skill, intelligence, and superior education speedily found him employment under Sir William Chambers, in the building of Somerset House. His merit soon became so conspicuous that he was soon after entrusted with the superintendence of certain works for Government at Portsmouth Dockyard; and in 1787, in his thirtieth year, he was appointed Surveyor of Public Works in Shropshire, a situation which he held till his death.

In 1790 he was employed by the British Fishery Society to inspect and report upon the state of the harbours at their respective stations; and he devised the plan for that extensive establishment at Wick, in the county of Caithness, which is known by the name of Pulteney Town, a modern and thriving suburb of the ancient and royal burgh, and now in every respect, save antiquity, regarded as the town, and Wick as the suburb. Prior to the time of Telford, its site was a large barren heath on the entailed estate of Hempriggs. He designed the harbour, the streets, and a certain number of buildings adapted solely for purposes connected with the herring-fishery, which in the season finds employment for more than a thousand boats, the crews of which are Highlanders, Norsemen, and Dutchmen.

In the years 1803 and 1804 the Parliamentary Commissioners for Making Roads and Building Bridges in the Scottish Highlands appointed Telford their engineer, and under his directions more than 1,100 bridges were built, in some instances where none had existed before, and 860 miles of new road constructed in districts that prior to his day had no other tracks than the old war-paths or drove-roads of the men of Fingal's time and the clansmen of later years.

The new bridge of five arches across the Don (superseding the ancient and well-known "Brig o' Balgownie"), at Aberdeen, was built by Mr. Gibb from a design furnished by Telford. Each arch is of 75 feet span, with 24 feet of rise. Its total expense was £14,000, and though it was in an unfinished state during the tremendous floods of 1829, it escaped on that occasion without injury.

In all these and various other works executed by him in his native country, in England, and in Wales, his wonderful skill enabled him to surmount natural obstacles and difficulties of the greatest magnitude; but the most stupendous undertaking in which he was engaged, and perhaps the most imperishable monument of engineering fame, is the Menai Suspension Bridge over the Menai Strait, one of the most magnificent works in the world.

It was full time that some such means of crossing the strait were constructed, as between the years 1664 and 1842 no less than 180 persons had been drowned at the Ferry of Moel-y-don. So early as 1810 more than one design for a bridge had been designed, and rejected as impracticable; and it was not until the completion of the great Holyhead road by Telford, that he saw the absolute necessity of devising some safe means of crossing. He selected a spot called Ynys-y-moch, where the bold and rocky shores on each side gave opportunities for a lofty roadway, which was carried 100 feet above high-water mark, so as to allow vessels of the largest size to pass underneath. It is difficult for the eye to estimate the colossal proportions of this wonderful bridge in the air, and it is only after attentively observing the vehicles and human figures crossing it, and looking in the distance through the high trellis-work of iron like flies in the web of a spider, or sparrows fluttering in a net, that it is fully appreciated. A sensible vibration is produced by the passage of a vehicle, or even a man and horse; but it has withstood the greatest storms of wind almost without injury. The weight which the chains support is calculated at 489 tons, and that which they are capable of supporting, at 2,016 tons, leaving an available power of 1,520 tons to resist any unusual strain. The total cost of its construction was £120,000. The masonry is of a hard limestone from Penmaen in Anglesea.

Prior to this work, in 1808, Telford was employed by the Swedish Government to survey the ground and lay out an inland navigation through the central part of the kingdom, with the view of forming direct communication by water between the North Sea and the Baltic. Plans for this purpose had been devised, but vainly, in earlier years. In 1516, Bishop Brask proposed to connect Lake Wettern with the Baltic; Gustav I. thought seriously of it. Charles IX. was the first to commence the undertaking by opening a port called Carls-Graf to avoid the upper falls of the Göta River. In the reign of Gustavus Adolphus a commencement was made of the Hjelmar Canal, but it was not completed till 1701. At a later period surveys of a line between the Wettern and the Baltic were taken by Daniel Thunberg, and in 1793 a company was formed for making the Trollhatten Canal by Eric Nordevall; but the real founder of the great Göta Canal was the Baron Baltazar von Platen, who in the year named, 1808, "summoned the famous Scottish engineer, Thomas Telford, and in twenty days the whole line was marked out nearly over the same ground as that contemplated by Daniel Thunberg." The work was chiefly done by the infantry of the Swedish army; and when, in 1813, Telford again visited Sweden, the gigantic undertaking was in full progress, but it was not fully open until 1822.

The genius of Telford was not, however, entirely confined to his profession. In early life he was a contributor of many pieces of considerable poetical merit to "Ruddiman's Weekly Magazine of Edinburgh Amusement," a periodical published then by the Brothers Ruddiman, in Foresters Wynd, which opened off the Lawn-market. These effusions appeared under the signature of "Eskdale Tam;" and he addressed, in rhyme, an epistle to Robert Burns, a portion of which has been inserted by Dr. Currie in his well-known life of the poet. Though he

soon relinquished, as unprofitable, the task of rhyming, he remained a poet all his life.

"The poetry of his mind," it has been said, "was too mighty to dwell in words and metaphors; it displayed itself by laying the sublime and beautiful under contribution to the useful for the service of man. His Caledonian Canal, his London and Holyhead Road, are poems of the most exalted character, divided into numerous cantos, of which the Menai Bridge is the most magnificent one. What grand ideas can words raise in the mind to compare with a glance at that stupendous production of human imagination?"

The most important of Telford's public works was the planning and laying out of the Caledonian Canal, a magnificent line of inland navigation $60\frac{1}{2}$ miles in length, through Glen Mhor na' Albyn, or the Great Glen of Caledonia, which extends due west and north-east from the isle of Lismore, in Loch Linnhe, to the sutors of Cromartie, on the Moray Firth. This great canal was one of a series of improvements which had peculiar reference to the Highlands and the condition of its people at that time, and was pressed upon the Government as a means for checking that emigration which threatened to leave all that part of Scotland a wilderness. It was proposed by Telford that the canal should be wide enough to admit the largest class of Baltic and American traders, or even a fully armed 32-gun frigate, with an uniform depth of 20 feet of water, and with locks measuring 170 feet long by 40 feet wide. His original estimate for this, and cutting the necks of land connecting the chain of locks, was no more than £350,000; but ere the great undertaking was concluded the sum amounted to £1,023,628, £43,500 of which was spent in obviating legal opposition and chicaneries alone.

It would appear that the present traffic on the canal is probably not $2\frac{1}{2}$ per cent. of the whole trade going through the Pentland Firth. The average of tonnage passing through the canal, exclusive of steamboats and local traffic, has been about 20,000 tons per annum. To prevent the delay—sometimes of three or four months—of going round Cape Wrath during westerly winds was one of the principal objects of the canal; but this end is defeated by the circumstance that as it lies in the trough, or hollow, between two lofty ranges of mountains, the wind blows always parallel to the line of the canal, so as necessarily to be a foul wind in one direction; and, consequently, as ships can neither tack nor be tracked by horses, the whole length, which ought not to occupy more than four days, takes at times as many weeks.

Steam-vessels are now, however, placed on the canal, and the whole scenery, from Corpach to Inverness, is so singularly romantic and sublime, that its character is greatly enhanced by the passing and repassing of large vessels gliding over the bosom of these vast lakes under the shadow of lofty mountains and forests of birch and fir, thus fulfilling the prediction made by a Highland seer, four centuries ago, "that vessels with white sails would be seen traversing the lonely Glen of the Lakes."

It was opened from sea to sea, according to Telford's plans, after twenty years of labour, on the 23rd of October, 1822.

Telford was a Fellow of the Royal Societies of London and Edinburgh; and from its commencement, in 1818, was annually elected President of the Institution of Civil Engineers. His gradual rise to the summit of his profession is to be ascribed, not more to his genius, his consummate ability and persevering industry, than to his plain, honest, straightforward dealing, and the integrity and candour which marked his character throughout life. He died unmarried, at his house in Abingdon Street, Westminster, on the 2nd of September, 1834, and was buried in Westminster Abbey.

TECHNICAL DRAWING.—LXVI.

DRAWING FOR BRICKLAYERS.

When the soil on which a building is to be erected is very soft or swampy for a considerable depth below the surface, which is the worst kind of foundation that can occur, it has been usual to secure the base of the walls by a wooden grating or platform of the nature described in the last lesson, but supported upon strong piles of a length sufficient to penetrate into harder soil, and acquire a fixture there, and which are driven until they will go no deeper. Such piles are usually shod with iron, and are driven at intervals of three or four feet apart. There ought to be at least two rows of piles under the foundation of every wall, as in the example shown in Fig. 531, so that every pair of piles support a transverse sleeper.

Less than two rows of piles would not give sufficient stability to the wall even of a common building. More than two rows, or three at the utmost, can only be required for the foundation of very substantial masses of masonry, such as revetments, wharf walls, etc.

The principle of the stability derived from a piled foundation is thus described by Sir Charles Pasley:—"By the laws of mechanics the force of percussion greatly exceeds that of simple pressure by dead weight; and in the pile-engines used in this country the ram (sometimes called the 'monkey')—that is, the weight by which the pile is driven—falls upon the head of it

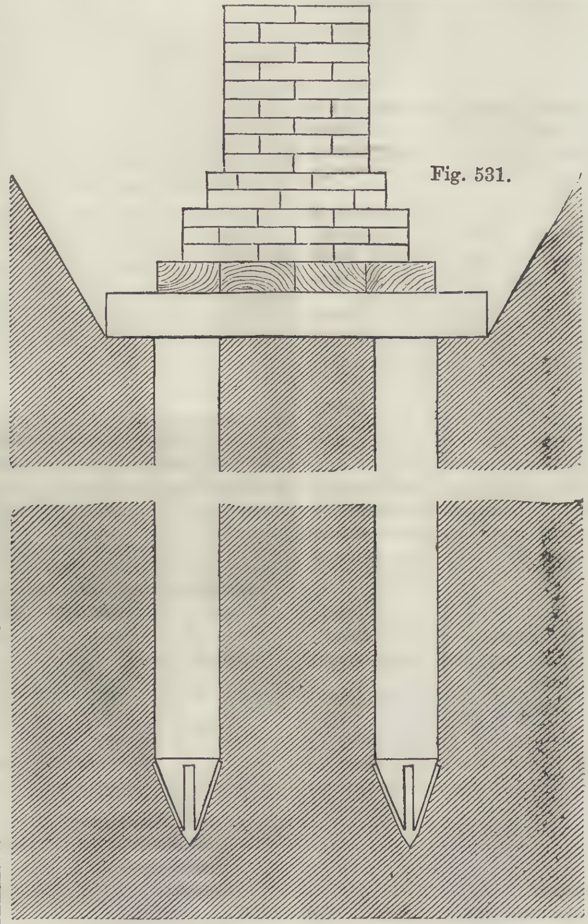


Fig. 531.

from a considerable height, which greatly increases the effect as compared with the old system of pile-driving still used abroad, in which the ram is not raised more than four or five feet. Now the momentum of ten or twelve hundredweight, a common weight for the ram of a pile-engine, falling from the height of fifteen or twenty to thirty feet, produces a greater effect than the dead weight of any common mass of building; hence, if a pile be driven by such an engine until it can go no further, there can be little risk of the foundation giving way afterwards in consequence of the mere pressure of the walls."

Foundations built on piles are, however, liable to failure, first, from the piles losing their original position in consequence of the soft ground offering too little resistance against a lateral movement, so that the walls built on them may have a tendency to fall over. The different forms of wooden and iron piles, the pile-driving machine, and the steam pile-driver are described in lessons in "Building Construction," Technical Educator, Vol. I., page 57.

In order to guard against this evil, the piles for walls are sometimes driven obliquely, so as to diverge at bottom, and those especially for leaning revetments or for the abutments of bridges may be driven in such oblique directions as to oppose the greatest resistance to the unequal pressure, which acts chiefly on one side of the wall.

Secondly, a failure may arise from wooden piles rotting or being corroded by worms in process of time, the former of which evils is almost sure to occur in foundations alternately wet and dry. Fortunately, the kind of soil where piles are most required is that where water is found a little below the surface; and if the woodwork be kept at such a level as always to remain wet, there is little or no risk of its decaying by rot. The perfect state in which trees have been found after the lapse of many centuries is well known. A few years ago, on throwing two arches of Rochester Bridge into one, the piles of the intermediate pier, which must have been there for several centuries, were taken up perfectly sound.

Reverting to the system of wooden platforms in foundations, they are of course liable to decay in process of time under most circumstances.

Now, since the uniform thickness of such platforms cannot exceed a few inches, this kind of failure taking place after the building has become completely consolidated, will not be attended with those injurious consequences which would arise from the decay of a piled foundation. Still, it is desirable to avoid using continuous planking, and to employ a couple of parallel longitudinal timbers for the same purpose, laid at a sufficient interval apart, which, when surrounded by brickwork or masonry, are called *chain timbers.*

These are shown in Fig. 532, in which is shown a section of a portion of one of the walls of the buildings in Lancaster Place, adjoining Waterloo Bridge, London. In this illustration, which will be further described presently, two parallel chain timbers are seen in section. These, which are in thickness about equal to the height of four courses of brickwork, are laid upon transverse sleepers placed parallel to each other at certain intervals.

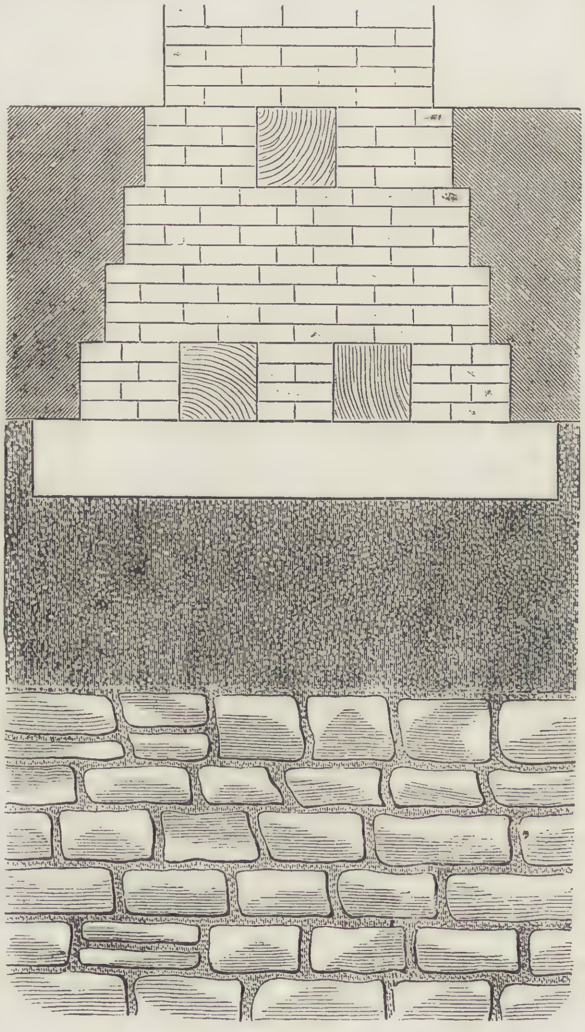


Fig. 532.

In this arrangement it will be evident that in the event of the woodwork decaying, the base of the wall will have a sufficient and solid footing on the natural ground or on the surface which has been prepared for it to rest on; for the intersecting cavities in the brickwork occasioned by the rotting of the timber are too small in themselves, and at too great intervals apart, to injure the stability of the brickwork.

It will be understood that the chain timbers which extend all round the building, and which therefore must be in several pieces, are firmly connected at the ends by scarfing or otherwise, and they are pinned down to the sleepers on which they lie. A third chain timber is also used, not on the same level with the others, in which case it might weaken the wall too much, but in the middle of the thickness of the wall, two or three feet higher up, as, for instance, at the part where the uppermost offset of the footings terminates. This third chain timber is also shown in the example, and it will be evident that the three combined will produce nearly the same favourable effect in the first instance as a continued planking, but without being liable to any of its inconveniences.

The buildings referred to are founded in very bad soil, which proved on examination to have consisted originally of soft mud, but which was intersected in all directions by the remains of the foundations of old houses and wharves. Trenches having been cut to a sufficient depth and width along the proposed line of the new foundations, fragments of the old walls were laid therein as regularly as possible, in the same manner as large flat stones might have been used. These were well sluiced with water, then mixed with grouted gravel,* and rammed down flat; the work being thus continued until the fragments alluded to were expended. Then the rough foundation was continued to the proposed footing of the brickwork with grouted gravel alone, and at that level transverse sleepers were used at intervals of about four feet apart (all under piers, none under the position of doors or windows), upon which were laid two longitudinal chain timbers of the thickness of four courses, completely surrounded by the brick, but immediately under, and flush with what was intended to be the exposed surface of the principal wall of the building after the work should be raised to a certain height; and a few feet higher, opposite to the top of the uppermost offset of the brick footing, a third chain timber of the same scantling was bedded in the middle of the wall. Thus these three chain timbers combined cover a space of not less than 2 feet 3 inches wide, being equal to the thickness of a three-brick wall, and this arrangement is continued throughout the whole extent both of the external and cross or party wall of that row of buildings.

The foundation here described is everywhere 8 feet wide, and of the same average depth. The brick footings have a base of 5½ bricks, which, by four successive offsets on each side at intervals of three courses apart, diminishes at the height of 3 feet to 3½ bricks, which is the thickness of the front and back walls of the lowest storeys of the buildings, which are vaulted and used as stables or stores. Over this the walls of the basement floor, and the inhabited part of those buildings, are 3 bricks thick, which dimension is gradually diminished by successive offsets to 1½ bricks in the uppermost storey of the house.

The height from the top of the brick footing to the coping of the parapets in front and rear is not less than 88 feet, to which, adding the footings and foundation, it appears that there is a mass of brickwork, rough masonry, and grouting nearly 100 feet in height—that is, on the side nearest the river.

* *Grout.* A thin semi-liquid mortar, composed of quick-lime and fine sand and gravel, which is poured into the internal joints of masonry; it is particularly used where the work consists of large stones. The process is called "grouting."

SHIP-BUILDING.—XII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS.

In our remarks on this subject it will be desirable to follow the same order as was followed in describing the skins of wood and composite ships; the arrangement or disposition of the plates being first considered, and afterwards their fastenings.

The outside surface of a wood ship's bottom is flush, and in some of the early iron vessels the plating was also made flush by means of the plan illustrated (in section) by *a* in Fig. 34. It will be observed that the edges of adjacent strakes of plating are connected by narrow plates or strips, fitted inside them, and riveted to each. The strips being made continuous in a longitudinal sense, it was impossible to fit the plating directly upon the frame angle-irons, and it became necessary to fill in the spaces between the plates and the frames with pieces of iron, termed "liners;" these are shaded across in the section for the sake of distinction from the plating and strips. A flush outer surface was thus obtained, but at considerable cost. The liners, for example, taken together amounted to a considerable weight, and added nothing to the strength of the hull. Then, again, the fact that the edges of the plates were flush-jointed, necessitated more care in fitting them and caulking them, than would have been needed if lap-joints had been used; besides which the amount of riveting required in the edge-fastenings was double that needed for lap-joints. In fact, the plan was wanting in economy of material and workmanship, and it gave place to others very soon; it has, however, been again used in a few ships built recently on the Tyne.

a *b* *c* *d*

Fig. 34.

The section marked *b* in Fig. 34 shows the "clinker" plan of plating, which was formerly much used in iron ship-building, the name being derived from the resemblance of the plan to that followed in planking wood boats and small vessels. Here the upper edge of each strake is fitted directly upon the frame angle-irons, and is overlapped by the lower edge of the adjacent strake. All the edges are therefore lap-jointed, and a considerable saving in weight and cost of workmanship was consequently effected, as compared with the flush-jointed plan. Liners were still required, however, to each strake, and they will be seen to be triangular or tapering in section; thus needing to be specially shaped in order to properly fit the spaces between the plating and the frames; whereas on the other plan the liners were of parallel section, and could be cut from plates.

The next section, *c*, represents the arrangement now used almost universally, in plating iron ships. Alternate strakes are worked directly upon the frame angle-irons, and are termed "inner" or "sunken" strakes. The intermediate strakes overlap the inner strakes at both edges, and are known as "outer" or "raised" strakes. Liners are thus required only to one-half the strakes, and at the same time are of parallel section, so that little care is needed in fitting them; while all the advantages of lap-joints, as respects saving in riveting, weight, etc., are obtained. The fact that this plan has been so generally adopted furnishes sufficient evidence of its superiority to the two preceding plans.

The fourth section, *d*, represents a plan of plating which has not been much used, but possesses some advantages. It is usually known as "Lamb's Patent," but there is reason to believe that it had been suggested previously to the date when this patent was obtained. All the strakes of plating are worked directly upon the frame angle-irons, liners being entirely dispensed with, and their weight saved. The flush edge-joints are then secured by continuous strips, resembling those fitted in section *a*, but worked outside instead of inside the plating. Of course, this arrangement necessitates twice as many rivets being used for edge-fastenings as are required in either the clinker plan, or the in-and-out system; and it also requires the edge-strips to be twice as broad as the laps, thus adding a weight which probably exceeds that saved on the liners. On the other hand, the later plan possesses some advantage in simplicity, and the directness of connection between the plating and the frames; it entirely does away also with the necessity for using liners that do not contribute strength to the hull. Hitherto, however, ship-builders prefer the in-and-out plan, and do not seem inclined to use the other.

Many plans besides the preceding have been proposed, but have not found favour. The use of two thicknesses of plating for the skins of iron ships has been repeatedly patented, some persons preferring to work both thicknesses longitudinally, and others to work them diagonally. The latter proposal, it need hardly be said, is based upon an entire misconception of the efficiency of the skins of iron ships. The use of two thicknesses of plating is confined in most vessels to a few strakes which are situated in critical parts of the structure where exceptional strength is required; and so far as we are aware the only instance of the more extended use of the plan is found in the skin-plating behind the armour of our iron-clads, illustrated in Figs. 24—26, page 224. In these vessels the double thickness is used to give greater resisting power to the target formed by the ship's side, rather than as a means of adding to the strength of the ship considered as a girder.

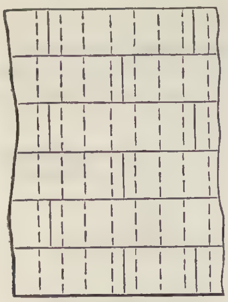


Fig. 35.

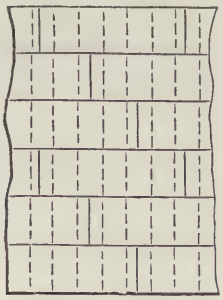


Fig. 36.

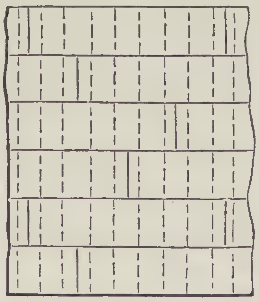


Fig. 37.

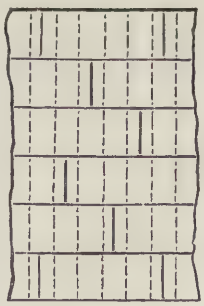


Fig. 38.

Other inventors have proposed to substitute special forms of plating for the plain sheets, or plates, generally employed. "Corrugated" plating has been advocated by some; "trough-shaped" plates by others; and still more singular forms that need not be mentioned. Against all these plans the great objection lies that they would necessitate considerable outlay on the mere *preparation* of the plating, besides causing more difficulty in its combination. In fact, ship-builders have unanimously declared in favour of the plain sheet-iron, which can be rolled with ease, and most efficiently combined; and this preference receives considerable support from the fact that the progress of the iron manufacture now enables much broader and larger plates to be procured than could formerly be

obtained. Twenty years ago the plates commonly used were not more than 2 feet broad and 7 or 8 feet long; and now plates more than twice as broad and twice as long can be rolled without difficulty, and are often used.

Attention will next be directed to the shifts of butts usually adopted for the plating of iron ships, examples of which are given in Figs. 35—38. Before describing these, however, it is proper to remark that the butts of skin-plating are not necessarily sources of weakness, while the butts of an ordinary wood ship's planking are unavoidably so. The plating is, as we have seen, pierced at each frame angle-iron by rows of rivet-holes, and thus weakened sections are produced. If the ship-builder, therefore, can make the sections of the plating at the butts as strong as the unavoidably weakened sections at the frames, he will have done all that is needed, and the butts will not be sources of weakness. This result may be attained by means of well-arranged and well-fastened butt-straps, as we shall show hereafter; and so a closer approximation to uniformity of strength may be made than is possible in the skin of a wood ship. At a section passing through a line of butts in the latter, every fourth (or butted) strake may be regarded as practically ineffective against tensile strains; whereas in an iron skin the butted strakes can be made as efficient as need be against both tensile and compressive strains. Consequently the iron ship-builder has a greater freedom than the wood ship-builder in disposing the butts of the skin; but he must exercise great care if he would fully develop the capabilities of the iron. Not only has he to consider the relative positions of the butts of the various strakes of plating, but also their positions relatively to the longitudinal frames or strengthenings; and a neglect of the latter consideration has in some cases caused serious weakness in ships otherwise well built.

In the sketches illustrating the various shifts of butts, the *dotted* vertical lines represent the stations of the frames, and the *drawn* vertical lines represent the butts of the strakes of plating, of which the horizontal lines show the edges. The first disposition, in Fig. 35, has only *one* passing strake between consecutive butts, and is termed the "brick" arrangement, from its similarity to the method of laying bricks in building walls, etc. It was formerly much used, and was not ill adapted to the short lengths of plating then procurable; it has, however, now given place (to a large extent) to the arrangement shown in Fig. 36, termed the "diagonal" plan, where there are *two* passing strakes between consecutive butts. In this arrangement it will be remarked that the butts of adjacent strakes form "steps," similar to those which wood ship-builders are so careful to avoid in arranging the butts of the outside planking; and it may be remarked that so long as a minimum shift of from three to four feet is secured between adjacent butts, iron ship-builders do not consider it essential to avoid such steps. The third arrangement, in Fig. 37, gives *three* passing strakes between consecutive butts, and is identical in principle with the ordinary shift of butts in the planking of wood ships, illustrated by Fig. 27, page 256. It is not very commonly used, but is well suited to cases where the plates employed are from 14 to 16 feet in length. Fig. 38 shows *four* passing strakes between consecutive butts, and is much used in the construction of merchant vessels. Unlike the plan in Fig. 37, it lends itself readily to the use of plates 9 or 10 feet long, and yet gives as great a minimum shift between adjacent butts.

The ship-builder would be mainly guided in his choice of the shift of butts by the lengths of plates he proposes to use, and in fixing the latter particular would naturally have regard to the relative cost of plates of moderate or of great length. Suppose, for example, a private builder had contracted to build a ship to be classed at Lloyd's. He would meet all the requirements of the Rules by adopting the shift of butts in Fig. 38, and yet not require lengths of plates exceeding 10 feet; whereas with the shift of butts in Fig. 37 he would require plates 14 feet long. Now the shorter plates would also be procurable at the cheaper rate per ton, and it would consequently be to the builder's advantage to use them, although the number of butts in the skin would be made greater in consequence. In another paper we hope to illustrate the close connection that should exist between the shift of butts and the character of the butt-fastenings; but for the present it must suffice to mention the obvious truth, that by increasing the number of passing strakes between consecutive butts a decreased amount of fastening will give the strength required to the butts.

The term "outside plating" is applied to the whole skin from keel to gunwale. The garboard strakes, coming next the keel, are usually thicker than the remainder of the plating; and the "sheer-strakes," coming in wake of the upper-deck beams, are also thicker by $\frac{1}{16}$ or $\frac{1}{8}$ of an inch than the plating on the sides, down to the turn of the bilge. The plating from this point in to the garboards is sometimes distinguished as "bottom plating," and is generally about $\frac{1}{16}$ of an inch thinner than the garboards. Some builders, however, use plating of uniform thickness over the whole space between the garboards and the sheer-strake. The "bilge-strakes" near the turn of the bilge usually have considerable curvature in a transverse sense, and are so made specially efficient, even when unstiffened by framing, against buckling under longitudinal strains. When additional longitudinal strength is required, one very common way of obtaining it is by doubling the sheer and bilge strakes, by means of another thickness of plating worked upon them, and having the butts carefully strapped and shifted from those of the plating on which the doubling plates are fitted.

The plates used have their maximum breadth and thickness at the midship section. As the girth of transverse sections rapidly diminishes towards the extremities, the breadths of the individual strakes have to be diminished also, and some of the strakes often have to be stopped short of the stem. A similar arrangement has frequently to be adopted with strakes of planking in wood ships, and in both cases the strake abutted is termed a "stealer." Beyond the end of the stealer the two strakes which were adjacent to it on the midship section are broadened, so as to occupy the space that would otherwise be left vacant. In the case of a wood ship this can easily be done, but in an iron ship special devices are needed in order to properly secure and caulk the butt of the stealer. The thicknesses of the plates are also usually diminished towards the extremities by $\frac{1}{16}$ or $\frac{1}{8}$ of an inch; it being considered that the strength required at those parts is much less than that needed amidships. Allusion having already been made to the discussions that have taken place on this question of reduction in the scantlings at the extremities, we need only add that hitherto no definite conclusion has been reached, practical experience and the requirements of local strength having far more weight than purely theoretical considerations.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XI.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY (*continued*).

We now proceed with the measurement of work done by joiner and ironmonger's fittings which was commenced in the last number.

GROUND FLOOR.

15 0 12 0	180 0	1¼ in. tongued batten floor, with iron tongues.
2) 4 0 0 9	6 0	Add recess.
6 6 2 0	13 0	Add bay window.
3 3 0 9	2 5	Add door.
	201 5	
3 6 1 6	5 3	Ddct. hearth.
	196 2	
7 0	7 0	1¼ in. mitred border.
43 0 1 3	53 9	1¼ in. mouldd. and rebd. skirting in 2 heights.

No. 10 tongued and mitred angles to skirting.

	43 0	43 0	1 in. skirting grounds, plugged.
	6 6 5 6	35 9	Solid oak frames, rebd. and mo., 4″ × 3″, with mullion and transom, mitred and beadd. sill, 2 in. lamb's-tongue casement, circular on plan (measured nett), $\frac{1}{4}$ in. rise.

No. 2 pr. 2 in. brass b. and s. 2 brass casement fastgs.
,, 2 brass hook and eye.

	6 6 5 6	35 9	$1\frac{1}{4}$ in. 2 panl. bd. flush and sqre. shutters, hg. with brass pulleys, pat. lines, lead wts.
	13 0	13 0	Groove for beads.

No. 1 brass thumbscrew and plates.
,, 2 brass sk. flush rings.

	6 6 0 4	2 2	$\frac{3}{4}$ in. mahogy. flap.

No. 1 pr. $1\frac{1}{2}$ in. brass b. and s. 1 brass flush ring.

	5 6 1 6	8 3	$1\frac{1}{4}$ in. 2 pl. mo. window back.
	23 0 0 5	9 7	1 in. framd. and bdd. grounds.
	23 6	23 6	$1\frac{1}{4}$ in. arch. mouldg, $3\frac{1}{2}$ in. wide.
	25 0	25 0	1 in. picture grounds, $3\frac{1}{2}$ w., plugged.
	7 0 3 3	22 9	2 in. deal 4 pl. mo., b. s. door.
	17 6 1 3	21 11	$1\frac{1}{2}$ in. deal framed linings, 2 pl. jambs, 1 pl. soffit, moulded and dble. rebd.
2)	18 3 0 5	15 3	1 in. framed ground.
2)	19 0	38 0	$1\frac{1}{4}$ in. arch. mo., $3\frac{1}{2}$ in. w.

No. 1 pr. 4-in. brass b. and s. 1 6-in. 3 bolt $\frac{5}{8}$-in. mortise lock, and china furniture.
,, 2 pr. china finger plates.

	7 6 3 6	26 3	$2\frac{1}{4}$ in. oak 6 pl. bolection mouldd. b. s. door, lower panels bead flush 1 s.
	3 6 2 0	7 0	2 in. oak ov. fanlight, circular head.
	15 0	15 0	$1\frac{1}{4}$ in. arch. mo., $3\frac{1}{2}$ in. w.
	6 6	6 6	Ditto circular.

No. 1 10-in. draw-back lock. 1 patent latch.
,, 2 escutcheons. 1 pr. 5-in. brass b. and s.
,, 2 10-in. brass barrel bolts. 1 brass rack chain.

	6 6 4 6	29 3	Dl. cased frame, oak dble. sunk, weathd. and throatd. sill, 2 in. ov. sashes, dble. hg. brass pulleys, patent lines, i. wts.
2)	6 6 1 2	15 2	$1\frac{1}{4}$ in. mo. and bd. flush foldg. shutters, panels in 2 heights.
2)	6 6 1 0	13 0	$1\frac{1}{4}$ in. bd. fl. and sqre. back flaps.
	17 6 0 7	10 3	$1\frac{1}{4}$ in. proper boxings.
	13 6 0 9	10 2	1 in. plain back linings, tongued.
	4 3 2 3	9 7	$1\frac{1}{4}$ in. mouldd. 1 pl. window back.
	4 3	4 3	$\frac{3}{4}$ in. capping.
2)	2 3 1 0	4 6	1 in. plain elbows, rebd.

No. 2 elbow caps. 2 soffits to boxings. 1 brass sash fastening. 1 w. i. shutter bar and plates, 3 ft. long. 2 pr. 2 in. b. and s. 2 pr. $1\frac{1}{2}$ in. back-flap hinges and s.

	23 0 0 5	9 7	1 in. framd. grounds.
	23 6	23 6	1 in. arch. mo., $2\frac{1}{4}$ w.
	3 6 3 3	11 5	1 in. mahogy. fram. seat and riser, Fr pold.
	3 6	3 6	Mold. nosings to ditto.
	3 6 1 9	6 2	1 in. mahogy. beadd. flap and frame, Fr. pold.
	7 0	7 0	$\frac{1}{2}$ in. mahogy. sqre. skirtg., 4 in. w., ditto.

No. 1 hole cut and dished. 1 beadd. hand-hole.
,, 2 roundd. corners to skirting. 1 pr. $1\frac{1}{2}$ in. brass b. and s.
,, 1 $\frac{3}{4}$-in. quarter round mahogy. shelf, 9″ × 9″, on chamfd. fillets.

	7 3 2 6	18 2	2 in. dl. clamped dresser top.

No. 2 rounded corners to ditto.

	7 0 0 9	5 3	$1\frac{1}{4}$ in. beadd. front to dresser.
2)	3 0 0 6	3 0	1 in. beadd. drawer fronts.
2)	7 6 0 6	7 6	$\frac{3}{4}$ in. dl. dovetailed sides to drawers.
2)	3 0 2 4	14 0	Ditto tongued bottom.
	9 6	9 6	Runners.
2)	2 4 0 9	3 6	$1\frac{1}{2}$ in. ends to dresser.
	12 0	12 0	Wrot. and framd. legs $2\frac{1}{2}$ in. sqre.
	7 0 2 6	17 6	1 in. pot board.

	12 0 0 4	4 0	1 in. riser.
2)	5 0 0 9	7 6	$1\frac{1}{4}$ in. cut and dimd. standards.
3)	7 0 0 9	15 9	$1\frac{1}{4}$ in. shelf.
	21 0	21 0	Groove.
	7 0	7 0	$\frac{1}{2}$ in. stop.

No. 3 doz. brass hooks. 4 ebony drawer knobs.

9 6 7 0	66 6	$2\frac{1}{2}$ in. mahogy. lamb's-tongue shop sashes.
7 0 2 6	17 6	Ditto circular, quick.
7 0 3 6	24 6	2 in. ditto astragal and hollow folding sash doors, dimd. stiles, lower panels, mo. and bd. flush.

No. 2 pair patent swing centres. 4 brass handles.

18 0	18 0	Mahogy beadd. door frame, 3″ × 3″.
9 6 2 0	19 0	$1\frac{1}{2}$ in. dl. mo. and sqre. stall board.
2 6 2 0	5 0	Ditto circular on plan, quick.
9 6	9 6	Mouldd. edge, 4 in. girt, to stall board.
2 6	2 6	Ditto circr. on plan, ditto.
14 6 3 0	43 6	Cradling to entablature, ploughed and tongued blockings.
14 6 1 6	21 9	1 in. dl. keyed frieze, joints feather tongued, lower edge rebd. for soffit.
14 6 0 4	4 10	1 in. rebd. soffit.
16 0 1 6	24 0	Dl. mould. cornice.
13 2 8 0	105 4	Revolving wood shutter with worm and wheel gearing.
8 6 3 0	25 6	$1\frac{1}{4}$ in. mahogy. counter top, glued and blocked.
6 0	6 0	Mortised clamps to counter-top.
6 0	6 0	Heading joint.

No. 1 fitting and hanging flap. 1 pr. 2 in. brass b. and s.
„ 4 mitres.

3 0	3 0	Wrot. and chamfd. mahogy. fillet.
11 6 3 0	34 6	1 in. mahogy. framd. front, mod. and sqre.

SOLDIERING.—IV.

BY A STAFF OFFICER.

EQUIPMENT ARMS (*continued*)—ARTILLERY.

In speaking of the "big guns," as they are usually called, I said that we might include among them all pieces larger than those which a man can carry. The large guns are, however, again subdivided into several classes, each implying some distinctive character in the organisation with which it is connected. Thus we have, first of all, the broad distinction between the "field artillery" and the "garrison artillery." The former comprises all those guns which accompany an army in its movements in a campaign and in battle; the latter comprises those which are too large and heavy to be so used. The field artillery is again subdivided into "horse artillery," "field batteries," "position batteries," and "mountain batteries." The horse artillery is intended to act with and support cavalry, with which it has therefore to be trained. The field batteries are the special support of the infantry. They also, however, usually form the main bulk of the artillery as an arm of the service in the field. It is, therefore, an error to lay it down as an axiom or point to start from in discussing their character, that they are *intended* to work with infantry. Every arm of the service is intended to do its part in contributing as much as possible to the efficiency of the whole. We shall, therefore, consider in due time how far their equipment determines for the field batteries what that part is. At present we must be content with noting the reason for the broad distinction between the horse artillery and the field batteries.

We require to have certain guns which *can* move with and support cavalry. As those guns must be able often to be moved at a gallop for great distances, and at all times at the same rate as cavalry ordinarily moves, it is clear that they must not be very heavy. Moreover, with these weapons there is another difficulty in very much increasing the size of the piece; for as the gun is made larger, the ammunition you have to carry with it becomes rapidly much heavier in proportion to the number of rounds. As, therefore, we cannot afford very much to diminish the number, we must on this account also restrict the size of the gun which is specially intended to accompany the cavalry.

But we want also to have with us, in a condition to be used as effectively as possible, the heaviest guns we can get. Moreover, we want to be able to place these just where they will be most effective, and, time being always of value, to place them there as rapidly as possible. Now it is quite possible for a gun to be moved very rapidly about which would yet be altogether too heavy itself, and would require too heavy ammunition, to fulfil the condition of moving with cavalry. This has led to the formation of the "field batteries."

Once more, it is quite possible that though a gun may be too heavy to be moved rapidly about the field and put just in the positions in which it is wanted at every moment, yet that if we once knew where the really decisive point was, a few such very heavy pieces might be moved up thither. Now as very heavy guns produce an immensely greater effect, both physical and moral, than the lighter kinds, it is well worth while to have, for the special purpose of being brought up to the most desirable point at the most decisive moment, a certain number of such guns. This consideration has led to the formation of "batteries of position."

The purpose for which "mountain batteries" have been formed is sufficiently indicated by the name. Obviously a gun must be of very light construction which is intended to be able to accompany the army by any mountain foot-path.

In general, the means by which the several degrees in the need of free movement of the different classes of guns (with the exception of the mountain gun) is met, is by an employment of horses adapted to the work required. So essential to both the horse artillery and the field batteries is rapidity of movement that the horse is almost as much an element in their actual fighting equipment as he is with the cavalry. The extreme importance of good horsemanship for the artillery requires some explanation. A gun cannot be fired whilst it is being transferred from place to place. The gun always travels with its back part or "breech" towards the horses' heads. It has to be "unlimbered," as it is called—that is, unhooked and turned round—before it can be loaded, pointed, and fired. Moreover, as the distance is very

considerable at which artillery always opens fire, that distance can only be guessed very roughly. A trial shot at least, if not more, has to be expended before a sufficiently accurate estimate can be made of the range or distance of the object aimed at. Hence every movement made by artillery from place to place represents a serious loss of power, due less to the distance moved over than to the number of moves. Moreover, if a thoroughly good commanding position has been taken up at first, the artillery gains little by being only *rather* nearer to the enemy. To the infantry every advance is a clear gain, both in the effect with which their fire can be brought to bear, and in their approaching nearer for the final rush. The artillery, on the other hand, if they can fairly see what they are firing at, can modify the distance at which their shot strikes, within such a very wide margin, that it is not worth while for them to move, except over a considerable distance. Nevertheless, very distant artillery fire is never very effective. It is in the comparatively close firing, where the effect of every shot can be seen, that the power of artillery comes out in all its deadliness. Artillery cannot be too close, provided it is just out of effective infantry range, and in a good position.

At the beginning of an action, moreover, the artillery is usually pushed forward into the most advanced positions which have been already secured by small bodies of the infantry. This is done in order that the two points in which it is superior in its fire to the infantry—its long range and weight of projectile—may be made to tell with their full effect on the enemy's position before the infantry moves forward to the attack. But as the artillery fire from these first positions begins to take effect, the enemy's fire slackens and the infantry is able to advance. The infantry thus secures positions from which the artillery can act with far greater effect. It is then that the artillery has to be moved at great risk rapidly and boldly forward. Hence, for the field batteries, which are the portion of the artillery mainly concerned in bringing crushing fire to bear on the enemy's position, the two great necessities are, as they are also for the horse artillery, rapidity and facility of movement:—the one, in order that as short a time as possible may be wasted in the ineffective period of advance, and that the guns may be allowed to remain a long time at the same spot, yet be brought up at the moment when they are wanted to a new one; the other, in order that the positions selected for the guns may be chosen so as to obtain the most effective fire, and that wherever such considerations would suggest that guns ought to go there they may be able to go. Now, these two necessities of rapidity and facility of movement can only be provided for by having the horses in the highest possible condition, and both horses and men trained in the highest possible degree.

Thus the horse, though he does not with the artillery aid as he does in the cavalry in the actual blow by which the power of the weapon is made to tell, is yet so intimately concerned in paving the way for each successful effort of the guns, that he is as essential an element in the fighting power of a battery as he is in that of a squadron.

There are six horses to each gun, and of these the three on the left-hand or near side are ridden postilion fashion by three men, each of whom also drives the horse beside him. Two gunners sit immediately behind the horses on the front of the gun-carriage. This front consists of two boxes, each carrying ammunition, *i.e.*, shell and cartridges; solid shot being never carried by artillery in the field. (For the different classes of shell carried see the papers on "Weapons of War.") Each front of a gun-carriage is thus a small field magazine for the supply of its own gun with ammunition. The whole gun-carriage when put together forms a four-wheeled vehicle. When the gun is unhooked, the front part, or "limber," forms a two-wheeled cart carrying the ammunition-boxes. The gun when unhooked rests partly on the axle-tree arms of the other two wheels, and partly on the point or end of a solid block of wood called the "trail," which supports the bed on which the gun rests. When the gun is thus in action the end of this trail rests on the ground. In order to hook the gun on to its carriage, the end of the trail, which consists of a solid iron eye, fastens into a solid iron hook at the back of the "limber." After the gun has been unhooked it can be moved by hand for considerable distances, if a sufficient number of men are available to work it, and the ground is not very heavy. The trail is lifted by three men, while as many others as are available work the gun forward by pushing at the spokes of the wheels. This explanation applies both to the horse artillery gun and to that of the field batteries. Each, too, has a wagon attendant upon the gun. This wagon consists of a limber exactly similar to that of the gun-carriage, and a "wagon body." The latter is a sort of double limber, having four ammunition-boxes instead of two. The whole wagon forms a four-wheeled carriage. The wagon body hooks on to its limber just in the same way as the gun hooks on to its limber. The limber of the wagon can, as soon as the ammunition in that of the gun is exhausted, move up and take its place whilst the limber of the gun is being re-filled from the body of the wagon.

It is essential that the wagon should be placed as completely out of danger of being struck by one of the enemy's shells as it can possibly be; for there is no object whatever in the wagon being exposed to the same extent to which the gun must often be to the enemy's artillery. The gun has its position selected quite as much with a view to enable it to fire with effect as to be itself safe. The wagon cannot fire at all. It has no means of acting whatever by itself, being simply a magazine of ammunition. Its size is very much greater, and therefore affords a very much more conspicuous mark than the gun when the latter is in action. For the wagon remains with its limber attached to it and all the horses hooked into the limber, while the horses and limber of the gun are taken out and sent to the nearest convenient protection. Above all, if the gun is struck by a shell, it does not at all follow that any irreparable injury is done to it; if the wagon is struck by even a large splinter, that splinter may cause all the large store of ammunition contained in the wagon to explode. Now that store is so great that it is quite sufficient to explode, one after another, all the other wagons, and by the general explosion destroy the limbers and guns also, unless the wagons have been removed to a safe distance. At the battle of Speicheren, during the war of 1870, an entire battery was thus swept completely away. Not another round was fired from it. Almost every man in it was killed. The entire destruction was due to one shell, part of which struck one ammunition wagon and exploded it. He would be a very bold man who would undertake that any battery in which a wagon not far removed to the rear had exploded should ever fire another round. The question, therefore, under the present conditions of all efficient fire, is one vital to the existence of artillery. For the horse artillery it is one easily solved; for the field batteries the solution has not yet been found, or at least applied; and it is at this point that the great distinction between the arrangement of the two appears.

The horse artillery, the purpose of which is essentially different from that of the field batteries, requires an altogether different fighting equipment from that of the latter. As it is to act expressly with cavalry, a number of mounted men belonging to the battery itself ride with it. When the gun is to be unlimbered and brought into action, certain of these men, in addition to the two sitting on the limber of the gun, dismount in order to load, lay, and fire the piece. Others are employed to hold the horses of those who dismount, while some of the horses are held by the drivers of the centre horses. Cavalry actions are always quick, sudden, and short. Therefore, the artillery which accompanies cavalry requires to have with it very few rounds of ammunition. Accordingly, horse artillery never moves for action with its wagons. The wagons keep away at a safe distance, and when it is necessary to replenish the supplies with the guns, they send up their limber after the action is over. Thus there is hardly any danger of a wagon's exploding. If by chance one does explode, few men are injured, and the efficiency of the battery is not impaired. The field batteries, on the other hand, have, with the exception of the officers and a few non-commissioned officers, no mounted men riding with the battery. The men who are to lay, load, and fire, sit either on the limber of the gun or on the limber or body of the wagon. For ordinary times—for marches, that is to say, and even for the latest movements up to the moment of coming within range of the enemy—the plan is entirely satisfactory. Field batteries do not require to move very rapidly at such times, and the wagons can trot at a very good pace—can, in fact, move almost as rapidly as the guns. But when the gun is to move up to a position for action the whole difficulty of the case presents itself. It is far too dan-

gerous to allow the wagon to move forward where the gun is. Yet unless the wagon does accompany the gun, how are the men to get there who are to work the piece? The gun is wanted up in a great hurry. Till it can be moved to a certain position nothing can be done. The gun dashes up at a gallop. The wagon stops at the last point to which it can safely move. Often it is necessarily delayed even at a more distant point; for during that last critical movement when the enemy's position is being approached, no portion of the army can be allowed to encumber the way which is not capable of bringing direct action to bear against the enemy. The wagon, therefore, a mere magazine and transporting carriage for men, has to allow masses of infantry to pass it. The gunners dismount and rush up after the gun. But men cannot race with horses, and the gun has all along had a considerable start over the wagon. The gunners, therefore, from the wagon arrive panting and unfit for work many minutes after the gun has reached its destined position. Those minutes are all precious. It is not possible to fire from the exact spot where the horses are obliged to drop the gun. The very reason for the selection of the position is, that there is a convenient bank a few yards off where cover will be just sufficient for the guns and the view perfect. Yet it is hopeless, with the only three men available, to push the gun by hand over the heavy ground intervening. All waits for the artillery. The infantry cannot advance a step till some relief has been obtained from the deadly fire of the enemy's position. It is a time when every officer in the brigade, from the youngest subaltern of infantry to the brigadier-general himself, has more than enough to do with his own work. All eyes and thoughts are strained in watching the enemy's position. Yet no one but the brigadier and his staff are near enough to the guns at the critical moment. Already the enemy have seen the tall headgear of the drivers showing over the bank. In another moment they will have found the range, and may render it impossible for the guns to open fire at all. Down jump brigadier and staff, abandoning all thoughts and cares, lending hard mechanical aid in pushing forward the guns into position. This is no fancy picture. An account of how it occurred in the Crimea may be read in Mr. Kinglake's description of the bringing up of the 18-pounders at the Alma. The remedy was then pointed out. Yet during the autumn manœuvres of last year (1871), in the attack on the Hog's Back, exactly the same thing occurred again as happened seventeen years before. Brigadier-General Browne and his staff assisted personally in pushing forward the wheels of the guns that were brought into position at the village of Seale. Newspaper correspondents applauded the zeal displayed by the officers. Others may, perhaps, mingle with their applause some regret that such waste of power should be necessary. The price in the labour market of a man who can push a wheel is not quite so great as that of one who possesses the capacity to govern 5,000 men. The moment chosen for placing the brigade commander under the necessity of taking part in the mechanical employment, is precisely the one when his higher powers are of exceptional value.

Experiments are now being made with the intention of ascertaining how the difficulty can best be met. It is to be hoped that a satisfactory solution may be arrived at; for it is useless to disguise the fact that since brigadiers can scarcely be provided to work every gun, till some other means of having men to work them, when they are wanted, have been found, our splendid field artillery can scarcely enter upon a campaign at all without the most serious risk.

Various means have been employed by different armies for avoiding the difficulty. Our own Indian artillery used to have gunners on the three horses at present driven, not ridden, by the drivers. The Prussians have men seated on two boxes on the axle-trees of the gun itself. These, with the three men who can be put on the limber and the non-commissioned officer who rides in charge of the gun, manage the handling of the piece fairly well. Our present experiment consists in providing the men with seats on the axle-tree boxes. Unfortunately, we have forgotten to provide them with any satisfactory support for their feet, and the bars to their seats are so uncomfortable that it is by no means easy to ride in them. The gun-carriages have no springs, and cannot have any; for travelling as they necessarily do over very rough ground, only a strong simple construction can be employed. Hence, as the moving a gun often requires very considerable exertion, and the men ought to be quite fresh and up to hard work when they dismount, it is very necessary that their travelling should be made as little fatiguing to them as possible. When the difficulty has been satisfactorily met, either by some means of this kind, or, which is no doubt the easier and simpler plan, by adding one or two more mounted men to the complement of the battery, the field artillery will be able to assume its own definite position and proper place. At present it is, from the circumstances I have explained, in so precarious a condition that it is indispensable to note the changes that must sooner or later be made in it.

The "position batteries" are drawn over the ground by large teams of strong horses intended simply for slow draught, not for manœuvring purposes. Hitherto we have not had any of them formed and kept ready for work in the way in which our horse artillery and field batteries are. But the guns are made, and occasionally they are horsed for the purpose of some large review or for practice. Obviously the same high training is not necessary for those who are to drive and direct them, in order to enable them to move satisfactorily, as they are required. But for them in proportion high training in the use of their weapon for shooting purposes is indispensable, as it is indeed also for both the horse artillery and field batteries. Of this subject I shall, however, have to speak somewhat more fully by-and-bye. At present it is the distinction in the characteristics of the several artillery weapons, as determining the nature of their organisation and use, on which I wish to fix attention.

The mountain guns are usually carried on the backs of mules; the gun on one mule, the gun-carriage on another. These are dismounted and put together when required for use.

In addition to the other classes of weapons which I have enumerated as belonging to field artillery we now include the mitrailleuse; for it has recently been recommended, by the committee appointed to investigate the question, that this instrument shall be employed like other classes of guns in regular batteries. It has one important distinction from all other classes of artillery, however, and it is therefore here that it is convenient to notice what is, for all other kinds of guns, their specific characteristic. They all depend for their effect upon the great superiority both of the distance to which they can throw their projectiles and of the weight of these projectiles themselves over the distance and weight of infantry fire. But the gunners cannot both attend to the handling of their big gun, and at the same time use any small weapons which will enable them to protect themselves if any body of armed men gets close up to the gun and among them. The big gun cannot be well handled against the multitude of small ones over which it has under these circumstances no advantage from its superior range of fire. The gunners, if alone, are therefore helpless victims to the fire of the assailing infantry. Hence artillery can never be left to protect itself. It always requires an escort to guard it. The whole efficiency of its action turns on its being employed just out of the effective range of infantry fire, or at greater distances than that. Thus, though artillery is alike valuable to the army which is on the offensive, and to the army which is on the defensive, its value to the army on the defensive depends on its power of striking such heavy blows against the assailant that he is not able to commence his operations effectively, rather than on its capacity for actually defending the position against him on which it is itself placed. Now the function of the mitrailleuse is the exact opposite of this. It scatters its storm of bullets most effectively from just beyond the range of ordinary infantry fire up to the ground in front of its own muzzle. Hence its action is essentially defensive—defensive of the very spot on which it is placed. It would be too much to say that mitrailleuse batteries will not require, like artillery, escorts to protect them; for they will require all the attention of the men who work them, who will, therefore, be personally unarmed; and at best these men will not escape when defeated so easily as the infantry can do, without abandoning the weapon.

We need not concern ourselves further for the present with the characteristics of the weapons of the field artillery. The yet heavier pieces which are employed by the men who form what is known as our garrison artillery are of one or two kinds. Either they are too heavy to be moved about at all, when they are kept either in fortresses or in batteries specially designed

for coast defence; or they are such as would be required by an army for the purposes of a siege. In either case the first special characteristic of the weapons which affects the character of the organisation and training of the men who work them is the great size and weight both of the guns themselves and of the projectiles which they throw. From both of these, but more especially from the immense size and weight of the guns, it results that mechanical skill of the highest kind is required to move them without an undue expenditure of labour. Every kind of material appliance has to be used, and the men have to become not only, as it has been well said, "skilled mechanics," but mechanics skilled to *work together* in a way that few mechanics are accustomed to work. But this is not all. From the size of the projectiles it is possible (as those will have seen who have studied the papers of THE TECHNICAL EDUCATOR specially devoted to the arms now used) to render them immensely more effective by elaborate workmanship. The explosive materials used are of the most terribly destructive kind, and their care requires a special training of its own. Hence on all these accounts the care and management of the weapon in all its parts, gun and projectile, requires and properly occupies all the attention of such men as are to be really skilled gunners; more especially since, where such enormous masses are to be thrown by a single piece of ordnance, it is of the utmost importance that they should be accurately thrown into the very place where they are intended to create destruction; and therefore the training of the gunners to shoot well requires much time and care. There is one point which is a common characteristic of all classes of artillery weapons. When a very great effect is to be produced upon any one part of an enemy's position, the purpose is to throw into that part as many projectiles as possible. Hence, as guns throw their shot and shell from a very great distance, it is not at all necessary that the guns whose projectiles are all to hit the same place should be themselves all near together. Hence, since nearly always it is more important to produce a great effect at one point than a little effect at a great many, our great object is to concentrate the fire, but to scatter the guns; for since the scattered guns can concentrate their fire, they will be as effective against the enemy, and will be a smaller mark and less observable by him.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVIII.—LEONARD EULER, F.R.S.

BY JAMES GRANT.

THIS distinguished mathematician, who became Director of the Royal Academy of Berlin, Member of the Imperial Academy of St. Petersburg, Fellow of the Royal Society of London, and Corresponding Member of the Royal Academy of Sciences at Paris, was the son of humble but respectable parents, Paul Euler and Margaret Brucker, and was born on the 15th of April, 1707, at Basle, in Switzerland. "The years of his infancy," says M. Fuss, "were passed in a rural retreat, where the example of virtuous parents contributed greatly to form him in that amiability of character, and uncommon purity of sentiments and manners, which were manifested during the whole course of his life."

Though the wishes of his father, then pastor of the village of Riechen, were that Leonard Euler should study for the Church, he preferred science, and applied himself with success to mathematics under the celebrated James Bernouilli, who in 1687 had been appointed a professor in the university of Basle, which had long ranked as one of the most famous seminaries in Europe. Euler attended its classes with strict regularity, and as his memory was wonderful, he performed his tasks with rapidity, and all the time he gained was devoted to geometry, which became his principal study. Euler hence became the favourite pupil of Bernouilli (then esteemed one of the first mathematicians in the world), whom his genius and rapid progress inspired with genuine admiration.

In 1723, Euler took his degree as Master of Arts, and on that occasion delivered a Latin discourse in which he drew a skilful comparison between the philosophy of Newton and the Cartesian system. He afterwards applied himself to the study of theology and the Oriental languages, and he became the friend and intimate associate of the two sons of Bernouilli, Nicholas and Daniel, through whom it was that his connection with the Academy of St. Petersburg came to pass. Peter the Great's project of erecting that academy was afterwards executed by Catherine I., and on the two young Bernouillis being invited to the Russian capital in 1725, Euler promised to follow if they could procure for him a suitable appointment; and in the meantime he applied himself to the study of physiology, and attended closely the medical lectures of the most eminent professors at Basle.

While thus engaged, he composed a "Dissertation on the Nature and Propagation of Sound," and an answer to a prize question concerning the *masting of ships*, to which the Academy of Sciences adjudged the *proxime accessit*, or second rank, in 1727. From this discourse and other circumstances, it would appear that the comprehensive mind of Euler had curiously enough been turned to the study of navigation—a study which he afterwards enriched by many valuable discoveries.

The lot of certain civil and academical honours which he deemed his due having been decided against him, he left Basle, not without a certain sense of mortification, joined Daniel Bernouilli at St. Petersburg, and with him became joint professor in the university. He now produced several memoirs and papers, and carried to new degrees of perfection the integral calculus, invented the calculation of functions, reduced analytical operations to a greater simplicity, and thus threw a new light on many parts of mathematical science.

In 1730 he was appointed Professor of Natural Philosophy, and three years after succeeded, in the chair of mathematics, his friend Daniel Bernouilli. In 1735 the Academy proposed a problem which required expedition, and for the solution of which the most eminent mathematicians demanded the space of some months. To the astonishment of the Academy it was solved by Leonard Euler *in three days*, but so laborious had been the task, that it cast him into a dangerous fever and deprived him of his right eye. The Academy of Sciences at Paris, which in 1738 had adjudged the prize to his memoir on "The Nature and Property of Fire," proposed for the year 1740 the subject of "Sea Tides," a problem requiring the most arduous calculations, together with a comprehension of the entire solar system. The discourse of Euler on this subject was deemed an exhaustive masterpiece, and it was thought more honourable for him to share the academical prize with such illustrious rivals as Daniel Bernouilli and Colin Maclaurin of Edinburgh, than to have carried it away from others of less reputation. "Rarely, if ever, did such a brilliant competition adorn the annals of the Academy; and no subject proposed by that learned body was ever treated with such accuracy of investigation or force of genius, as that which here displayed the philosophical powers of those three extraordinary men."

On being invited in 1741 to Berlin, where the Academy was then rising into form under the auspices of Frederick the Great, he enriched the last volume of "The Miscellanies of Berlin" with five memoirs which make the principal figure in that collection. With astonishing rapidity other papers followed on the most important subjects, and these are scattered through the "Memoirs of the Prussian Academy," which, ever since its final establishment in 1744, has published one volume annually. The labours of Euler were the more surprising, when it is borne in mind that he did not discontinue his philosophical contributions to the Academy of St. Petersburg, which granted him a pension in 1742, when he was in his thirty-fifth year; and it was with much difficulty that in 1766 he obtained permission from Frederick to leave Prussia and return to the Russian capital, where he was anxious to pass the rest of his life.

Soon after his return, when he was nobly rewarded by the munificence of Catherine II., he was seized with a violent disorder, which terminated in the total loss of his sight! A cataract had formed in his left eye, which had become seriously impaired by too close application to study, and thus he was deprived of the use of that organ; and it was while in this distressing situation, that the untiring philosopher dictated to his servant (who had been a tailor's apprentice, and was totally ignorant of mathematics) his "Elements of Algebra," a work which, though purely elementary, discovers all the characteristics of an inventive genius. It excited applause and astonishment by the circumstances under which it was composed; and in it alone is to be found a complete theory of the analysis of Diophantes, a mathematician of Alexandria, who flourished

before the Christian era, and an edition of whose works, with notes by M. Fermat, was published at Paris in 1670.

When his " Elements " appeared, the Academy of Sciences at Paris honoured him by naming him one of the foreign members of that learned body, and adjudged the prize to three of his memoirs concerning " The Inequalities in the Motions of the Planets." The two prize questions proposed by the same academy for 1770 and 1772 were designed to obtain from astronomers a more perfect theory of the moon.

Assisted by his eldest son, Euler, though totally blind, and in his sixty-fifth year, was a competitor for those prizes, and gained them both! It was a wonderful effort of genius to be able to arrange all his vast calculations by the power of *memory* alone, and when, by embarrassment in his domestic circumstances, a fire having consumed his library and much of his property, compelling him to quit a house which by long habit was familiar to him, he had to compose "a work which alone was sufficient to render his name immortal."

In the great fire of 1771, in addition to the loss of his library, he nearly lost his life. M. Grimon, a native of Basle, on learning that the flames had reached the house of Euler, boldly pressed through the conflagration, and rushing into the apartment of the blind philosopher, brought him out on his shoulders at the greatest risk. By the courage and ability of Count Orloff, the whole of his MSS. were saved.

In this last memoir he reserved for further consideration several inequalities of the moon's motion, which he had failed to determine in his first theory, on account of the complicated calculations in which the method he then employed had engaged him. With the assistance of his son, he had the courage to review his whole theory, and to pursue his researches until he had constructed the new tables, which, together with his great work on the moon, appeared in 1772. Working in darkness, " the heroic patience and tranquillity of mind he displayed need no description," to quote an eulogy of Euler; "and he derived them not only from the love of science, but from the power of religion. His philosophy was too genuine and too sublime to stop its analysis at mechanical causes; it led him to that divine philosophy of religion which ennobles human nature, and can alone form a habit of true magnanimity and patience in suffering."

About this time the famous Wentzel, by couching the cataract, restored the sight of Euler; but the satisfaction and joy of that restoration were of short continuance. By some negligence on the part of the surgeons, and his own impatience, perhaps, to use an organ the cure of which was not complete, he lost his power of vision a second time, and the relapse was accompanied by tormenting pain. However, with the assistance of his son, and Messrs. Kraft and Lexell, he continued those labours of science with an ardour which neither blindness nor the infirmity of advanced age could damp. His lunar tables were, at the suggestion of Turgot, rewarded by the Board of Longitude in France; and when the more perfect tables of Mayer obtained the great premium of £3,000 offered by the British Parliament, the sum of £300 was awarded to Euler for having furnished the theorems made use of by Mayer in his work.

In 1773, Euler published at St. Petersburg his great work on the construction and management of vessels. A new edition soon after appeared at Paris, and by desire of Louis XVI. it was introduced into the schools of marine, and a reward of 1,000 roubles transmitted to the author, accompanied by a handsomely worded letter written by the celebrated Turgot. Almost at the same time Italian, English, and Russian translations of it appeared, and the Government of Catherine II. presented Euler with a gift of 2,000 roubles. Though blind, in the course of seven years he transmitted no less than *seventy* memoirs to the Academy of St. Petersburg; and about two hundred more, that he had written or dictated, were revised for him by his friend Nicholas Fuss. "Euler's knowledge," says the latter, "was more universal than could well be expected in one who had pursued with such unremitting ardour mathematics and astronomy as his favourite studies. He made a very great progress in medical, botanical, and chemical science. What was still more extraordinary, he was an excellent scholar, possessing what is generally called erudition in a very high degree. He had read with attention and taste the most eminent writers of ancient Rome. The civil and literary history of all ages and nations were familiar to him; and foreigners, who were only acquainted with his works, were astonished to find in the conversation of a man, whose long life seemed solely occupied in mathematical and physical discoveries, such an extensive acquaintance with the most interesting branches of literature. No doubt, in this respect, he was much indebted to his most uncommon memory, which seemed to retain every idea that was conveyed to it from reading or meditation. Hence he could repeat the 'Æneid' of Virgil from beginning to end, and indicate the first and last lines of every page of the edition he used."

Several attacks of vertigo, in the spring of 1783, did not prevent him from calculating the motions of air-balloons, which at that time occupied the attention of philosophers. On the 7th of September he dined with M. Lexell, and spoke of the planet Herschel. Soon after he was amusing himself with one of his grandchildren, when on a sudden his pipe fell from his hand, and he expired of an apoplectic stroke, in his seventy-sixth year.

Euler was twice married, and had three sons and two daughters; the latter predeceased him, but twenty-six out of thirty of his grandchildren were alive at the time of his death, which was deemed a national calamity by the Russians, and the Academy of St. Petersburg decreed him a marble bust at their own expense. A complete list of his works occupies no less than fifty-one pages of Nicholas Fuss's " Elogé," which was published there, in quarto, in 1783; and a collection of the best productions of Euler appeared at Brienne, in eighteen volumes, in 1797.

Euler was a rigid Calvinist, and so long as his sight was spared he assembled the whole of his household every evening and read a chapter of the Bible aloud; he was wont to add a little exhortation or discourse, theology having been from his boyhood one of his favourite studies. His habits were ever sober and temperate; his manners unaffected and pleasing; his temper cheerful and happy.

THE LATHE.—VIII.

By Henry Northcott.

SLIDE-RESTS (*continued*)—MODERN HAND-LATHE.

The slide-rest illustrated at Fig. 25 is of more modern design than those hitherto noticed. This instrument is intended chiefly for operating upon metals, whilst the previous ones were adapted chiefly to act upon more tractable materials, and as a consequence of this difference in the nature of its work the present slide-rest is constructed wholly of iron, and of more massive proportions. In action it is precisely the same as those already described—that is to say, it has a foot-plate, *a*, which is planed underneath, so that it may bed nicely down upon the planed surface of the lathe-bed, and carry the various slides duly level and square. The slot shown along the foot-plate is, of course, for the holding-down bolt to pass through it.

It may be remarked here that the bottom surface of the foot-plate of any slide-rest should not only be planed and rendered smooth, but its area should be large, so that it may steadily support the slides against the pressure resulting from heavy and irregular cuts. If the foot-plate be too narrow, the whole rest becomes very unstable when a heavy cut is being removed from a piece of work, and this unsteadiness becomes especially noticeable when the tool is moved to the end of its slide on either side, as then the tendency of the strain upon the tool is to upset the rest or to depress the cutting tool. Many slide-rests are rendered almost unserviceable from having a foot-plate too narrow to firmly resist the pressure upon the tool.

The slide-rest also has a strong traverse-slide, *b*, with the usual screw and winch-handle, and also a surface-slide, *c*, the top part of which, *d*, is the tool-plate. The tool-holder is somewhat different from those heretofore described, consisting of a flat plate with three screws in it. The plan of this plate is triangular, and the three screws are placed one at each of the three corners of the triangle. The plate has a hole through its centre by which it is supported upon the central spindle, and the fit is a loose one, so that the plate may be swung round upon the central spindle, and placed in any position with regard to it. The tool is placed under two of the screws, and is fixed at any angle that the nature of the work may render

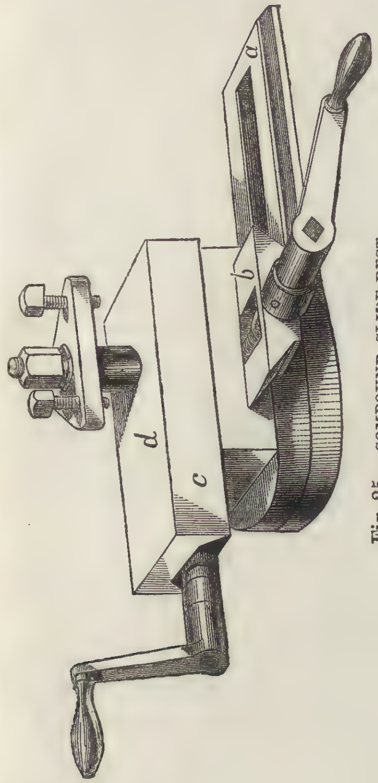


Fig. 25.—COMPOUND SLIDE-REST.

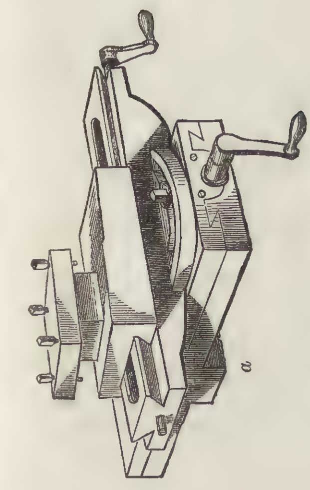


Fig. 26.—COMPOUND SLIDE-REST.

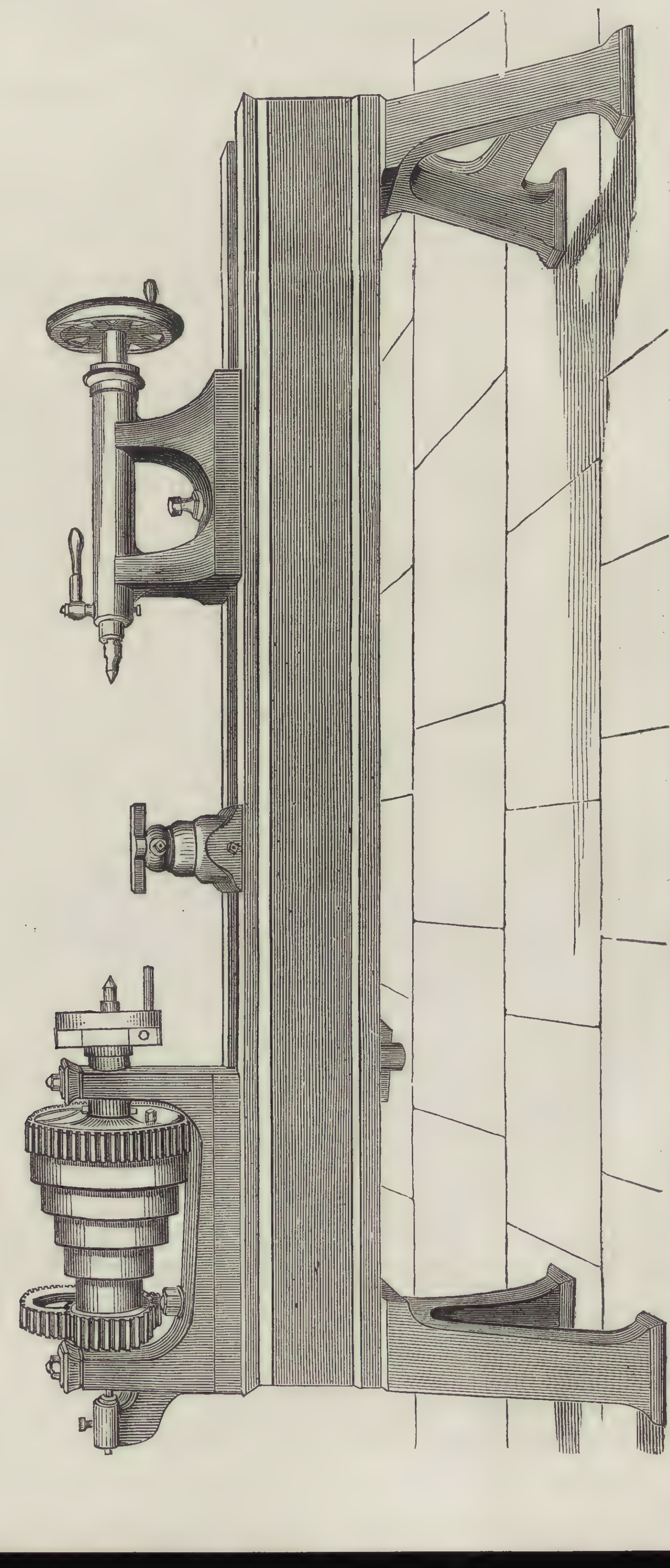


Fig. 27.—HAND-LATHE, CONSISTING OF TWO HEAD-STOCKS, CATCH-PLATE, FACE-PLATE, REST-SOCKET, AND TOP CONE-PULLEY.

necessary by tightening the two screws down upon it. The third screw acts simply as a support to the other corner of the triangular plate, to keep the plate horizontal, and prevent the two screws holding the tool down from throwing any cross strain upon the central bolt. A convenient and efficient tool-holder is quite essential to the satisfactory action of any slide-rest. This one is simple, and its principle is good, but in the example it is not so well carried out as it might be, and more favourable specimens will be met with hereafter. The three screws should in every case be made of steel and hardened throughout, but their points should be left somewhat harder than the thread of the screw, as they come in contact with the hard steel tool, which would otherwise flatten or "upset" the ends of the screws. It is advisable also that the plate should be of a good thickness, especially at the part where the screws go through it, as the continually screwing down so hard and unscrewing these screws soon wears out the thread if the plate be thin.

At Fig. 26 is shown another and more complete example of a compound slide-rest. This one also is constructed wholly of metal, and all the sliding surfaces are planed up, and should be scraped to a true surface. The projecting rib at *a* goes between the two slabs of the lathe-bed to preserve the parallelism of the traverse-slide, and the position of the rest generally. The arrangement of the traverse and surfacing slides is shown very clearly by the sketch. They are constructed in much the same manner as the previous ones, and it will be seen that the upper slide has an angular motion, with a curved slot and screw for the production of tapering and angular work. The tool-holder in this case has four screws, arranged one at each of the corners of a square plate. This plate is not movable, as the last was, around a central pin, but is firmly fixed to form a part of the upper plate. The tool is placed under any two of the four pinching screws, and there is thus a choice of four positions, any one of which may be chosen that the shape of the work may render most convenient. The choice of positions is much more limited than in the last example, and this is no doubt a disadvantage, but the holder is very strong and efficient in all other respects.

At Fig. 27 is shown a strong substantial lathe of modern design, for the execution of tolerably heavy hand-turning in either wood or metals, but chiefly in metals. The massive cast-iron bed is carried by two strong cast-iron standards, which are required to support it steadily. The surfaces where the standards come in contact with the under-side of the bed are planed, and they are bolted together, so that the bed and standards may be as firmly attached to each other as if they were one solid casting. The top surface of the bed also, and the inside edges forming the space between the two sides of the bed, are truly planed up to a smooth surface, so that the screw head-stock may be slid anywhere along the lathe-bed without affecting the position of the line joining the lathe-centres. The driving head-stock is, of course, firmly fastened down upon the lathe-bed, its bearing-surface being planed to fit properly down upon the surface of the bed. The rib projecting from the under-surface of the head-stock, instead of being made to fit nicely between the two slabs of the bed, is sometimes left much narrower, in order that the whole head-stock may be shifted bodily out of the usual line of lathe-centres. This provision, however, is only of use for sliding lathes, or with lathes having slide-rests with fixed slides, as the object of it is that with the tool following its usual course parallel to the proper line of lathe-centres, taper and angular work may be produced instead of ordinary turning. When the head-stock is so constructed two screws are placed through the projecting web, and so as to come across the space between the two planed edges of the lathe-bed, which they accurately fit. By turning these screws in the proper direction the position of the head-stock may be very nicely adjusted to produce any small amount of taper, or it may be adjusted to the slide-rest for producing a flat surface or a parallel shaft. Of course this arrangement is not required for lathes intended solely for hand-tool turning, nor for such as have slide-rests with shifting slides. With the first the shape of the work would be quite unaffected by the position of the lathe-spindle, and with the second the taper can be produced by shifting the slides, and without shifting the head-stock. The cone-pulley of this lathe has five speeds, and is adapted to receive a flat leather belt and to drive from a shaft overhead. The speeds may be still further varied by the double-gearing, in the manner previously explained. The small hand-tool rest shown in place upon the bed may be removed, and a slide-rest substituted, when the nature of the work renders it advisable.

PRACTICAL APPLICATION OF THE FINE ARTS.—XI.

THE ART OF MOSAIC (*continued*).

By P. H. Delamotte, Professor of Drawing, King's College, London.

In the practical application of fine art to mosaic, we must use those canons of art which are universally true, modifying these according to the material in hand. Of course, designs for the decorations of walls will be different from those for floors. The Romans certainly did put much good work and beautiful pictures upon the floors, much as we see handsome carpets now-a-days with bunches of flowers and even landscapes portrayed upon them. Still we suppose that scarcely any one could put his heavy boot upon the Cirencester Ceres or Flora without a pang; if his taste did not feel it, he would deserve a twitch of gout to remind him of what he ought to consider. It would be very inconvenient to be continually jumping about to avoid pressing an unhallowed heel upon some fair production of nature: we cannot, therefore, admit the representation of natural objects upon a floor intended for general traffic. It remains for us to discuss the character of designs that are admissible; and our choice is limited to colour and form.

In form we cannot do better than go back to the simplest patterns and the most classical models. The common Grecian border (Fig. 23, Cirencester), either in its ordinary form or as we have it here, is an unfailing source of pleasure to the eye. Another very common border, very convenient from the possibility of turning or stopping at almost any point, is the twisted cable, as shown in Fig. 22. The Grecian is slightly altered, by being adapted to what might be almost called oblique co-ordinates, and enclosed in a diamond-shaped compartment in the pavement from Threadneedle Street (Fig. 26). In this relic we have, too, another very common design, the endless knot, whilst square compartments are mingled with diamond-shaped ones, rhomboids affording a pleasing variety of oblique, acute, and right angles. In this, too, we have idealised flowers and leaves of two kinds. The endless knot and some of the other ornaments occur again in Fig. 25, from Cirencester, combined with some other very felicitous forms. The arrangement of eight rhomboids around a point in a shape somewhat approaching both a cross and a star, is very happy; and the introduction of regularly curved lines in the terminal border breaks the monotony of so many straight lines with no greater curves than those of the endless knot. In this example the cable is coloured on the inner side of a brownish-orange, whilst the two outer rows of tesseræ are nearly white; the same colours and arrangement hold good of the endless knots. The diamonds are separated by black lines; the interior of all of these are yellow; whilst the line immediately round the interior is black and orange in alternate diamonds, white coming again between this and the black.

In Fig. 20, from Abbots Ann, Hampshire, we have scarcely more than the idealised leaves of the former figure carried out a little further, and more idealised, and more geometrical; and in Fig. 21, within a similar border to some of the former, a more complicated figure is introduced, still, however, mainly founded on the cross and circle.

The next kind of ornament that we meet with is of a somewhat different character. It consists no longer of mere geometrical lines, straight and curved, adapted more or less to pleasing shapes, and sometimes approaching the form of idealised flowers and leaves; but we have now in such patterns as that from Cirencester (Fig. 24), and from Woodmanchester, in Gloucestershire (Fig. 19), the scroll-work of which the main foundation is the imitation of leaves and branches; still, of course, thoroughly idealised. This style of ornamentation can at the present day be carried into far higher perfection than was the case under the Romans, since the experience of so much mediæval and renaissance work, though the latter may be considerably overcrowded and redundant, has contributed greatly to a just taste in such designs. Too much cannot be done in this direction, where the material in hand will admit

of adaptation to this use. This will be the case especially when natural materials or *smalti*, as the small pieces of glass are called, are employed. These *smalti* are fragments of glass broken off larger cakes of six or eight inches long by four or five wide, and of a tolerably uniform depth of nearly half an inch. These broken pieces, of course, are not quite uniform in shape, so that the form can be chosen which is best adapted to the pattern in hand, whilst for flat surfaces the pieces most nearly approaching regular cakes are preferable. But if terra-cotta or other forms of clay manufactured in the shape of small tiles are employed, it will most naturally happen that these fall into regular geometrical patterns. Of course, where the subject is large, and the tiles employed are very small, and both cubical and triangular, a very near approach can be made to either a scroll pattern or an imitation of natural objects; but after all this is rather adapting a somewhat unwieldy material to a purpose alien from the best use of ornament, which consists in applying the material to the most pleasing effect of which it is naturally capable.

When the surface to be covered is a wall or piece of furniture, there is then no reason why a picture should not be imitated. Thus the great churches of Italy have their walls decorated, and these copies of the masterpieces of great painters carry to posterity a very close approximation of the original works unimpaired by the passage of time. We say a very close approximation, because however accurately a great work is copied—and the Italians are certainly great copyists in the best sense of the word—a copy can never convey the whole grace and beauty, and thought of the original, unless the hand and heart of the master be employed upon the copy, when, of course, it becomes no longer a copy.

But even of pictures, some are more suitable to this style of material than others. To a great extent the subjects suitable for fresco painting are also adapted for representation in mosaic. A study of great works in the various churches in Ravenna, of which photographs have been taken, will show the character of work which the early workers in mosaic thought best adapted to their material. Here we have the calm, placid figures represented in a dignified repose, such as one might expect would be consonant with the feelings of the descendants of the Greek sculptors of old. No excited emotions, but a calm dignity of feeling—not absolute rest, but a position of motion temporarily and naturally suspended; these characteristics lend themselves agreeably to the means in the artist's hand.

It is not granted to every one to have the means of studying the best models, nor is it by any means in the power even of those who ardently desire it, to design great works of art; but that is no reason why all who make attempts in any branch of art should not place before themselves the highest attainable model, and strive to the best of the ability they may happen to possess to approach as near perfection as possible in the works they take in hand. The constant exercise of all one's powers must lead to increased facilities and capabilities, and thus the hand, the eye, the taste, and the knowledge become expanded and strengthened, just as under the judicious training of a gymnast the muscles of the body gain both strength and rapidity of motion.

TECHNICAL DRAWING.—LXVII.

DRAWING FOR BRICKLAYERS.

THE MANNER OF LAYING BRICKS—THE TERM "BOND" DEFINED.

In building with bricks, as all the parts are equal and regular, they are laid in horizontal courses from the foundation upwards. The reason is obvious: regular bodies, such as bricks placed on a horizontal base and with vertical sides, have no tendency to move laterally. If, on the contrary, bricks were laid on an oblique base, they would have a tendency to slide downward in one direction. Hence the wall might eventually bulge or crack, or lose its perpendicularity.

If we suppose a wall of only half a brick thick, all the bricks used would of course be laid lengthwise, so as to show their whole length in the face of the wall, in which case they are called "stretchers" ("Building Construction," Vol. I., p. 141).

In laying a second course of bricks, care must be taken to prevent any two vertical joints from coinciding. This would be effected by placing the joints or meeting of the ends of the second course of bricks over the middle of the bricks of the first course. The same arrangement would be attended to in the third and in all the succeeding courses.

Fig. 533 is the plan and Fig. 534 is the elevation of part of a brick building in which the walls are supposed to be half a brick thick—that is, $4\frac{1}{2}$ inches—and built in the manner just described.

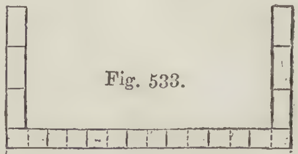


Fig. 533.

This arrangement of never allowing any two vertical joints to coincide is technically termed "breaking joint," and a wall thus built is said to have a proper bond—a term which implies that the parts are properly connected.

It will be observed that all the bricks represented in the elevation are stretchers, showing their whole length in the surface of the wall, excepting one brick at the angles of the wall in each alternate course, *a*, *a*, *a*, *a*, which shows itself in the elevation. A brick thus laid is called a *header*.

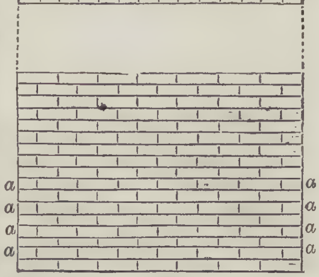


Fig. 534.

By this method of placing a header at the angle of each alternate course, a "bond" is obtained. If the whole were laid in stretchers throughout, as in Fig. 535, all the vertical joints would coincide, and the wall would only consist of upright piles of bricks, the entire weight of each pile resting on one brick below, and there would be no connection between the upright stacks but the mortar in the vertical joints, which would, of course, be insufficient to prevent either one from separating. This has been fully explained in lessons on "Building Construction."

It must be mentioned that the above example is introduced merely as an illustration of the necessity for correct bonding of the bricks; but walls of half a brick thick are not used in any proper building, being far too weak to afford the necessary stability even to the smallest buildings, unless the brickwork be held together by a wooden frame, of which it fills the intervals. This style of building, used for economy, is altogether unsuitable for public buildings, unless of a very temporary character, and is called *brick nogging*, specimens of which are seen in many villages.

Brick nogging is sometimes used for partitions in dwelling-houses.

All proper walls, then, are one-brick thick and upwards, and it is to be observed that in such, bond cannot be obtained without introducing parts smaller than a regular brick near each angle or opening—that is to say, not only at the corners of the walls, but also at each side of every door, window, or recess throughout the whole building.

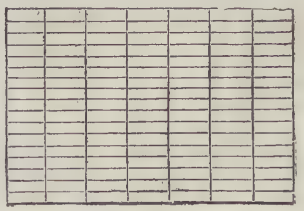


Fig. 535.

For instance, if we suppose a wall to be one brick (that is, about 9 inches) thick, the bricks may evidently be laid either as *headers*, in which case one brick laid across, front to back, occupies the whole thickness of the wall; or as *stretchers*, in which case two bricks laid alongside of each other in the direction of the length of the wall make up the thickness.

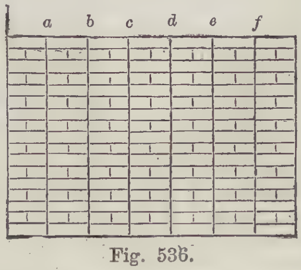


Fig. 536.

Now if we suppose Fig. 536 to represent the elevation of a wall in which the bricks are all of the regular full size, and laid headers and stretchers alternately and in successive courses, it will be evident that one-half of all the vertical joints, *a*, *b*, *c*, *d*, *e*, *f*,

must necessarily agree, because every two headers occupy in the face of the wall precisely the same space as one stretcher, and the effect would be practically the same as that shown in Fig. 535—namely, the wall would be formed of mere stacks one brick wide.

To obviate this inconvenience, which would render the bond very imperfect (since, although the vertical stacks are bonded together by the bricks of which they are formed crossing each other, it has been shown that they are only united by the mortar), small headers, only a quarter of a brick in width, are used near each angle, opening, or break in the wall, as was before mentioned, the utility of which will be evident on comparing Fig. 537, in which this method is represented, with the preceding figure.

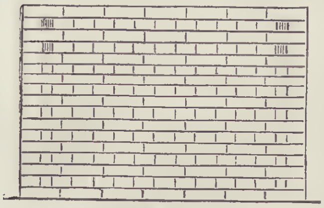


Fig. 537.

In this figure, some of the small headers are shaded, in order that they may be better visible. They are technically termed *closers*, and are further described and illustrated in lessons in "Building Construction."

On examining any brick building the student will at once see that this arrangement is generally followed, and thus a perfect bond is produced throughout the whole wall, it being observed that these narrow bricks appear in alternate courses only, and are the second brick from the angle of their respective courses, the first or corner brick of the same course being always a header.

Broken bricks are generally called brickbats; but the term *bat* is by workmen specially applied to the one half of a brick broken across the middle.

A regular bat, or half-brick broken a second time, produces two pieces, each a quarter of a brick in width and half a brick in length, which combine to form a closer. These pieces singly are called *half-closers.* When a brick is broken transversely into two unequal parts, the larger of the two is called a *three-quarter bat.*

The remarks hitherto made upon the bond of brickwork apply only to the external surface of the wall, as seen in elevation, which may be judged of by the eye. In walls of certain thickness, the internal bond, which cannot be seen or examined after the work is finished, is of equal importance.

Fig. 538 represents the section of a wall two bricks in thickness, in which the courses are supposed to be laid alternately, all headers and all stretchers, so as to correspond with the foregoing elevation, and yet, owing to a faulty arrangement of the bricks used, all the vertical joints in the middle of the wall coincide with each other. It will be evident that such a wall, although it would appear strong and perfectly bonded if the external surfaces only be examined, has no proper bond internally, for one vertical joint prevails from top to bottom, and from one end of the wall to the other; so that such a wall would be liable to split in two by a longitudinal fracture.

By adopting a different arrangement, as in Fig. 539, which represents the section of a wall of the same thickness, the above defect will be completely obviated, for it is evident that all the vertical joints, internal as well as external, are now perfectly broken, and that a sufficient bond is thereby obtained throughout every part of the wall.

Fig. 538.

Fig. 539.

It will hereafter be seen that it is often convenient, if not absolutely necessary for the purpose of obtaining the most perfect bond, to finish one side of a wall, not exactly, although nearly, in the same manner as the other, so that although both elevations may appear alike to an inexperienced observer, the arrangement of the joints of the one will in reality be less regular than the other. In this case the *face of the wall*, which in a building implies the external surface, being that exposed to view, must be finished in the most regular manner, in preference to the *back* or internal surface of the wall, which is eventually (at least in most cases) concealed from view by plastering or papering.

Having thus defined the term "bond" in general terms, and having entered into the subject at some length in lessons on "Building Construction," it is now proposed to give further instruction on this all-important branch of the bricklayer's work. In doing this, it may be necessary to repeat some few paragraphs or illustrations from the lessons on the general subject, with the view of showing their intimate connection with the present course of lessons. The student is urged to make himself thoroughly acquainted with the subject as a whole before proceeding with further detail. It is not, however, sufficient to read, even though that reading be accompanied by drawing: the instruction must be *realised*, and for this purpose a number of wooden bricks should be provided. These can be obtained from any carpenter, and may be of any convenient size,

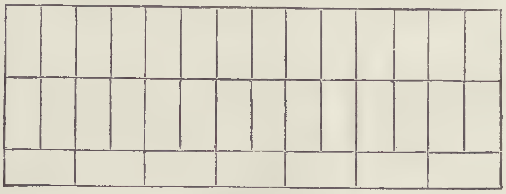


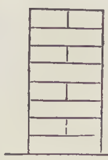
Fig. 540.

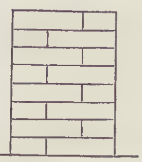
Fig. 542.

Fig. 543.

Fig. 545.

Fig. 546.





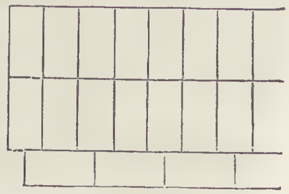


Fig. 544. Fig. 547. Fig. 541.

so long as the true proportions are kept up. About half the real size will be found best adapted for class teaching, whilst for private study quarter size will be sufficient. Amongst these model bricks should be bats (or half-bricks), closers (or bricks cut in half lengthwise), and also a few quarter-bricks.

With these the walls of different kinds and thicknesses, in two or three courses, should be built according to the instructions here given. The drawing will then be intelligently made, whereas it would otherwise degenerate into a mere copy of straight lines.

DRAWING FROM SOLID OBJECTS.

In all the examples hitherto given, *one surface* only has been shown of each of the subjects under consideration.

Now, for absolutely working drawings this is all that is necessary, such drawings being required to show the exact position

of every wall, or of cornice, sill, or step, so that the work may be executed according to the exact measurement of the design.

But if it be required to draw a house or any other object in such a manner that an impression of solidity may be given, further study and practice becomes necessary, and the student is referred for instruction on this head to the series of lessons on "Object Drawing" commencing at page 3, Vol. II. of THE TECHNICAL EDUCATOR.

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

We have in lessons on "Building Construction" given the general distinction between English and Flemish bond, and we

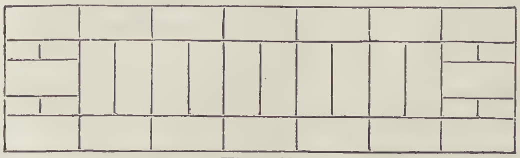


Fig. 548.

Fig. 549.

Fig. 552.

Fig. 553.

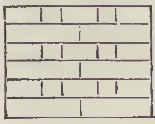


Fig. 550.

Fig. 551.

Fig. 554.

now proceed to the further elucidation of the subject, adopting the system laid down by Sir Charles Pasley, R.E.

COMMON ENGLISH BOND.

In common English bond, alternate courses of headers and stretchers appear on each side of the wall, so that the elevation of it is the same which has already been described in relation to Fig. 537. But with the exception of the stretchers, already mentioned, which appear externally, no others whatever are used, so that the remainder of the wall consists exclusively of headers.

In looking at a wall thus built, those courses where headers appear to the eye, are called *heading courses;* but those in which the stretchers appear, are called *stretching courses*, notwithstanding that the inside of the latter may be filled up with headers.

It is essential in common English bond, that the horizontal joints in each course shall never be broken, but that the bricks shall be so arranged that the whole of the opposite joints shall extend transversely in one and the same right line from one side of the wall to the other—that is to say, the bricks of the same course must always be arranged as in Fig. 540, not as in Fig. 541.

By attending to this rule this style of building will be found

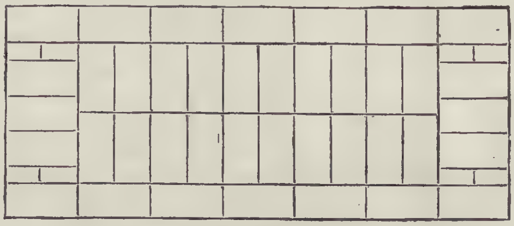


Fig. 555.

extremely simple. In a wall whose thickness is either one brick, two bricks, three bricks, four bricks, or any other dimension involving a whole number, the stretching courses agree on both sides of the wall; but if the thickness be one brick and a half, two bricks and a half, three bricks and a half, or any other dimension involving a half brick, that which is a stretching course on the one side of the wall is a heading course on the other side, and *vice versâ.*

In order to exemplify the common English bond thus described in general terms, we will suppose a portion of a brick wall equal to seven bricks in length, and terminating with both its ends at right angles to the general line of the wall. This portion of brickwork may represent part of a wall contained

Fig. 556.

between the openings of two adjacent windows. It is true (says Sir Charles Pasley) that the sides of windows are not now usually finished in such a simple manner; "it was, however, the method used formerly," and we will therefore suppose them to be so for the sake of illustrating the peculiar kind of brickwork now under discussion.

Fig. 542 represents the plan of the stretching course and Fig. 543 the plan of the heading course of a wall of this description—one brick thick. In the heading course it will be observed that closers are laid next to the extreme header at each end, without which the proper bond could not be obtained.

Fig. 544 is the section or end of the same wall.

Figs. 545 and 546 represent two successive courses of a wall of

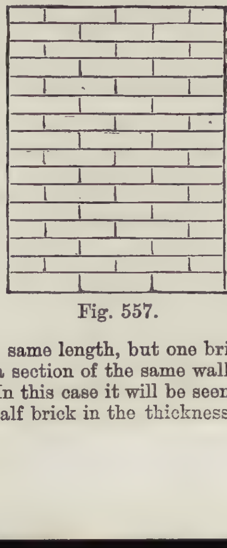


Fig. 557.

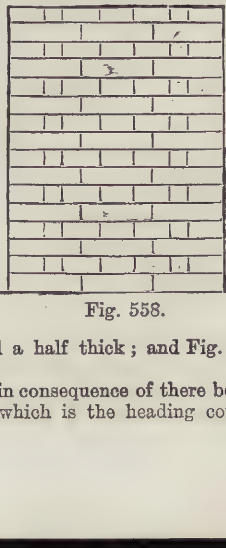


Fig. 558.

the same length, but one brick and a half thick; and Fig. 547 is a section of the same wall.

In this case it will be seen that, in consequence of there being a half brick in the thickness, that which is the heading course

in front is the stretching course in the rear of the wall, and *vice versâ.* At the ends of the wall three-quarter bats are used in alternate courses in order to obtain the proper bond.

In this example, too, it will be observed that the two sides of the wall are not exactly alike, and the same will occur in all walls built according to common English bond, in which half a brick is involved in the thickness of the wall.

Figs. 548 and 549 represent the plans of two successive courses of a similar wall of two bricks thick. On attaining this thickness the ends of the wall present a more considerable surface than in the former examples, and require to have their joints broken by means of a couple of closers in alternate courses, it being necessary to treat the square ends of walls of a certain thickness precisely in the same manner as if they were short portions of the front of a building. Fig. 550 is the section and Fig. 551 the end elevation of the same wall. Figs. 552 and 553 represent the plans of two successive courses of a wall of the same description, but of two and a-half bricks in thickness.

Fig. 554 is the end elevation of the same wall in which a half brick, shown also in Fig. 555, is necessarily used in the centre of each alternate course in order to obtain proper bond.

Figs. 555 and 556 represent in like manner the plan of two successive courses of a wall three bricks thick. Fig. 557 is the transverse section, and Fig. 558 the end elevation.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VII.—NATIONAL MUSEUMS.

In my article on Museums at page 358, Vol. II. of The Technical Educator, I have given a theoretical notion or Utopian idealisation of what *the aims* of a national museum should be. I shall now attempt to show how far such ideas may be realised in practice, under conditions which are sure to arise in a great city, that would prove antagonistic to the carrying out in its entirety any such scheme as I have therein suggested.

A review of all the facts connected with such a question are well worthy of the careful consideration of naturalists at the present moment, when through the exigencies of space at the British Museum, it has been determined, notwithstanding the grave objections, hereinafter stated, that have been raised by influential persons to separate the natural history collections from the antiquarian departments and the library of the British Museum, and remove them to a new museum now being erected on a plot of ground on the Gore Estate, on the site of the International Exhibition of 1862.

It behoves all who have any influence to see that the new National Museum of Natural History shall not be cramped in its future development for want of sufficient space; that the architectural arrangements and internal fittings meet the requirements of the day; and that its entire organisation shall be established on a true and proper basis for "arranging, preserving, and exhibiting in a fitting manner a natural history collection worthy of the country as well as of its capital, and intended not only for the special advantage of students and scientific men, but generally for the rational amusement and instruction of all classes;"* even whether it should not also embrace the aims of the Museum d'Histoire Naturelle in the Jardin des Plantes at Paris, as defined by the Directory of 1793, viz., "the advancement and teaching of the natural history sciences in all their branches and in their application to the arts and manufactures."

In commencing this inquiry, it is advisable to consider the objections that have been raised to the severance of the scientific from the antiquarian, artistic, and bibliothecal collections. Foreigners regard our British Museum unique as to its aims in collecting under one roof all attainable specimens illustrative of literature, science, and art, so that it may be "regarded as a consulting encyclopædia, a repertory for reference to all these departments of human knowledge."† But, nevertheless, while protesting against any breaking up of the present harmonious system, nor failing to notice that while our Parliament year by year, votes supplies for the purchase of additional specimens, it injudiciously does not allow of their proper display, by begrudging money for an extension of the galleries of a museum palpably over-crowded, many of our own countrymen expressed their objections not only on this head, but on the inconvenience that would be experienced if the natural history collections were separated from the scientific books in the Museum library. Others conceived that the natural history collections would be little visited if removed from their present central position to South Kensington, and on this score the severance would prove of especial inconvenience to working naturalists. So strong was this feeling on the question of dismemberment, that the late Sir Roderick Murchison, one of the trustees of the British Museum, declared before the committee that though he had bequeathed to the British Museum the colossal vase of Siberian avanturine granite presented to him by the Emperor of Russia, under the impression that it was the proper resting-place for such an embodiment of science and art, if the natural history collections were removed, it would affect that intention, and he should alter his will.*

For many years past Dr. J. E. Gray, as keeper of the Zoological collections, has, in his annual report to the trustees, called attention to the urgent necessity for providing additional space for the natural history specimens, those displayed in the galleries being as far back as 1848 inconveniently crowded, while many valuable specimens and collections were obliged to be stored in the vaults beneath the museums. Thus, in 1816, when Cuvier visited this country, mainly with the object of examining the only known specimen of the skull of the right whale, he had to be conducted by the light of a lantern to the lower regions of the British Museum. If any osteologist of the present day desired to inspect that skull of a right whale in a wrong place, he must descend to the same vault, and examine it by the same light, as in Cuvier's day. Since Professor Owen's appointment as superintendent of the natural history collections he has persistently urged the pressing necessity for additional galleries, or a new museum in some other district, as it was utterly impossible, under the existing state of things, for the officers of that institution to do justice to the national collections, for the proper keeping of which they are responsible to Government.

In 1858 both the trustees and the Government officers seemed to fancy that the only satisfactory way out of the difficulty was by providing a new museum for the natural history collections, and availing themselves of the space left vacant for the equally pressing wants of other departments; Professor Owen being requested to submit an estimate of space required, and a plan for a new national museum of natural history. This he laid before the trustees March 16th, 1859, including therein modifications of his scheme, to suit ground immediately adjoining the British Museum, or a site on the Gore estate *now* occupied by the west galleries of the International Exhibition, and the machinery sheds in Prince Albert's Road. Meanwhile a memorial had been forwarded to the Chancellor of the Exchequer by nine of our leading naturalists—viz., Bentham, Harvey, Henfrey, Henslow, Lindley, in the interests of botany; and Busk, Carpenter, Darwin, and Huxley, in those of zoology—dated November 18th, 1858, requesting a full consideration of the requirements of naturalists before any scheme or re-organisation was finally decided on, and stating their own convictions as to the arrangements best adapted to meet the twofold object of the advancement of science and its general diffusion among the public; and to show how far the scientific museums of the metropolis and its vicinity, in their present condition, answer their purposes, and to suggest such modifications and additional arrangements as appeared requisite, and to render them more thoroughly efficient. The opinions expressed in this memorial may be summarised by specifying the museum deemed necessary to meet the above stated object:—

1. A general and comprehensive typical or popular museum, in which all prominent forms or types of animals and plants, recent or fossil, should be so displayed as to give the public an idea of the vast extent and variety of natural objects, to diffuse a general knowledge of the results obtained by science in their

* See the "Treasury Minute" quoted in Panizzi's letter to the superintendent and keepers of the Natural History Departments, March 6th, 1862, Parliamentary Papers, 1864, Vol. XXXII.

† *Vide* Report of Select Committee on the British Museum, Parliamentary Papers, 1860, Vol. XVI.

* Since Sir Roderick's death this magnificent specimen of avanturine granite and work of art has been transferred to the Museum of Practical Geology, of which he was Director.

investigation and classification, and to serve as a general introduction to the student of natural history.

2. A complete scientific museum, in which collections of all obtainable animals and plants and their parts, whether recent or fossil, and of a sufficient number of specimens, should be disposed conveniently for study; and to which should be exclusively attached an appropriate *library*, or collection of books and illustrations relating to science, wholly independent of any general library.

3. A comprehensive economic museum, in which economic products, whether zoological or botanical, with illustrations of the processes by which they are obtained and applied to use, should be so disposed as best to assist the progress of commerce and the arts.

4. Collections of living animals and plants, or zoological and botanical gardens.

As zoologists and botanists, the memorialists offered no opinion as to the best disposition of the valuable mineralogical collections in the British Museum, and the economic collections in the Museum of Practical Geology.

The memorialists suggested that all the zoological collections with a select zoological library, together with a typical or popular museum of botany, for the convenience of those resident in the metropolis, should be placed under one direction, while the herbaria of the British Museum should be consolidated with the Kew collection, and be removed to a permanent building to be provided for their accommodation at Kew, and these, with a select botanical library, should be placed under one direction. That the directors of the Zoological and Botanical Museums should be directly responsible to one of Her Majesty's ministers for the proper management of the several departments. That the Museum of Economic Zoology at South Kensington should be further developed, and that the Museum of Economic Botany should be retained at Kew. That the existing collections should be separated into popular typical and student's scientific collections, and that while the former should be accessible to the general public every day in the week, the latter, with their respective libraries, should likewise be daily available to students of zoology and botany only. The economic and living collections should be available to the general public. The Typical and Economic Museums should be fully displayed in spacious galleries, in large buildings, in light, airy, and accessible positions. The scientific collections for the special use of working naturalists need only occupy small space in convenient studies, and be so arranged as to allow of the specimens being taken from their receptacles for direct examination.

This memorial, in connection with Professor Owen's estimate of space and plan for a new national museum of natural history, led to the election of the Select Committee of the House of Commons of 1860 to ascertain the requirements, created by the necessity for an increase of space, of the British Museum, and to the introduction of a bill to empower the trustees of the British Museum to remove the natural history collections, and other objects to any suitable place, notwithstanding the pressing necessities of the case as stated by Professor Owen, Dr. Gray, and other keepers of the natural history collections, as given before the committee, in correspondence between the Treasury and the trustees and their officers, and in the report of Professor Owen and the keepers of the Natural History Departments, March 16th, 1862. This bill was thrown out on the score of expense at the debate on the affairs of the British Museum, May 19th, 1862. It is amusing to note how thoroughly unconversant men of education and of the highest political status can be in regard to the requirements of science, and with the unity of natural history classifications. In his estimate and plan of March 16th, 1859, Professor Owen pointed out the necessity of acquiring skins and skeletons of the whale tribe, as illustrative of the greatest bulk attainable in the present epoch, and as one of the peculiarities of the Mammalian class, especially as the largest species, the right whale (*Balæna Mysticetus*) may become extinct, through its extensive slaughter by whale fishers, for the Museum only possessed the skull previously referred to, stowed away out of sight in the cellars. Further, he had estimated the length of the skeletons of the right whale at 95 feet, sperm whale 75 feet, bottle-nose whale 40 feet, grampus 30 feet, finner whale 20 feet, but by reason of their vast size such specimens, which would be of the greatest value to the naturalist, he could only expect to find accommodation for in "a national museum." He estimated the length of gallery for the *entire* Mammalian series at 850 feet. In the debate Mr. Gregory, who opposed the bill, exclaimed, "850 feet for the exhibition of whales!" in the same vein as Dominie Sampson gave vent to "prodigious!" Viscount Palmerston in his speech said, "Let me propose a compromise to my honourable friend: let him, when the House shall go into committee on the bill, introduce a clause prohibiting any whales. I have no doubt whales are objects of great interest, but sooner than go to the expense of paying £50,000 when we can get land for £10,000 an acre, I for my part shall be willing, with my honourable friend, to exclude whales altogether from disporting themselves in Kensington Gardens." This was said in all earnestness, and not, as might be supposed, in a spirit of banter.

In his plan of 1859, Professor Owen was understood to express a conviction that in a national museum the whole series of natural forms should be fully displayed to public gaze. Professor Flower, in commenting on this idea, observes:—

"Let the reader imagine what a public library would be if the books, instead of being shut up and arranged on the shelves for consultation when required, had every single page framed and glazed and hung on the wall, so that the humblest visitor as he passes along the galleries has only to open his eyes and revel in the wealth of literature of all ages and all countries, without so much as applying to a custodian or opening a case. There is something truly heroic in the conception of such a scheme; but laying aside all questions of space and cost, what would be its real utility to those who are able to appreciate and make true use of its contents! All the inconveniences, all the impossibilities, I may say, of a library arranged upon such a plan would be found in a museum containing anything like an adequate number of objects for the purposes of really enlarging the boundaries of scientific zoology, in which every specimen contained in it would be exposed to the gaze of all who chose to enter its walls" ("Nature," May 26, 1870).

In the leader of *The Times* of May 21st, 1862, commenting on the debate of the 19th of May, the writer observes—"Let Mr. Owen describe exactly the kind of building that will answer his purpose, that will give space for his whales, and light for his birds and butterflies. The House of Commons will hardly, for very shame' sake, give a well-digested scheme so rude a reception as it did on Monday night." But this Professor Owen had already done, not only in his revised estimate given in his report of March 6th, 1862, but in a lecture given at the Royal Institution, April 26th, 1861, fully reported in the *Athenæum* of July 27 (*et sequitur*), afterwards reprinted in a separate form, which reached a second edition in 1862,* and is now out of print. In that work Professor Owen enters fully into the various considerations that should guide the curator to a proper estimate of the requirements of all the great divisions of the three kingdoms of Nature. Therein he says, the first principle in the arrangement and allocation of such objects is, that each class should receive its due proportional amount of elucidation to the extent which the acquired specimens of a museum at the time may admit, and according to the degree in which the principle of variety is manifested in the class. "A museum of Nature does not aim, like one of art, merely to charm the eye and gratify or improve the sense of beauty and of grace." Many forms accord with our apprehension of the beautiful, such as richly plumaged birds, pearly shelled mollusks, brightly painted insects, branched corals, drooping fronded ferns, stately palms, gorgeous flowering plants, and glittering minerals. But there are other forms of unwieldly bulk, or repulsive aspect, that equally claim the study of the naturalist. "What then is needed for a co-equal or justly proportional representation of all the classes of animals (plants and minerals), to the extent in which a nation may possess or have opportunities to acquire the specimens of them?" First and chiefest, adequate exhibition space: how is this to be estimated? *First*, by the number of known species of the class; *secondly*, by the extent of exhibition space occupied by the proportion of the class which may be properly exhibited in any existing museum; *thirdly*, by the proportion of examples obtained, but not exhibited; *fourthly*, by the ratio at which such specimens have accrued in a given number of years; *fifthly*, by the circumstances or con-

* "On the Extent and Aims of a National Museum of Natural History." By Professor Owen, F.R.S.

ditions on which the ratio of future increase may be computed. Such requisite data I have as far as possible gleaned from the work of Professor Owen, and the various reports, etc., previously referred to and tabularised, not only for the purpose of saving space, but that the whole of such data may be taken in at a glance, for facilitating comparisons.

DATA AND ESTIMATE OF SPACE FOR THE NATIONAL COLLECTION OF NATURAL HISTORY.

	DATA, 1862, SUPPLIED BY EXISTING MUSEUM.							ESTIMATE FOR NEW MUSEUM.		
DEPARTMENTS.	NUMBER OF KNOWN SPECIES.	NUMBER OF SPECIMENS IN PRESENT MUSEUM.	NUMBER EXHIBITED IN PRESENT MUSEUM.	NUMBER IN STORE, STUDIES, &C. AT MUSEUM.	PRESENT LENGTH OF GALLERIES. FEET.	SUPERFICIAL AREA OF EXISTING GALLERIES, ETC., IN SQRE. FEET.	RATIO OF INCREASE OF SPECIMENS PER ANNUM.	LENGTH OF GALLERY. FEET.	WIDTH OF GALLERY. FEET.	AREA IN SQUARE FEET.
E 1 Ethnology . . .	30	500	—	500	—	—		150	50	7,500
Mammalia . . .	3,500	5,300	3,525	1,775	220	11,505		850	50	42,500
Aves	8,300	25,000	12,000	13,000	300	14,550		800	40	32,000
Reptilia . . .	2,000	7,000	910	6,090	70	2,330		300	40	12,000
Pisces	8,000	19,000	1,913	—	70	3,100		400	40	16,000
* 1, Osteology . . .	—	2,200	200	2,000	—	2,900	33,077	1,250	50	62,000
Mollusca . . .	16,000	140,000	100,000	40,000	278	14,200		300	50	15,000
Articulata . . .	220,000	—	—	—	70	3,100		250	50	12,500
Radiata. . . .	—	7,000	4,074	2,926	70	5,980		250	50	12,500
† 1, Embryological and Developmental Models	—	0	0	0	—	—		—	—	—
B 1, British Zoology .	—	—	—	—	—	2,550		—	—	—
Zoological Studies, Workrooms, etc.	—	—	—	—	—	2,235				
						62,450				
Botany . . . B 2, British Botany	213,000	—	—	—	80	5,500	—	200	40	8,000
Botanical Studies	—	—	—	—	—	—	—	—	—	—
2 * Palæozoology 3 * Palæphytology † 2 Stratagraphical Geology. Geological Studies	—	153,000	50,000	103,000	370	18,500	7,242	850	50	42,500
Minerals	652									
B 3 British Mineralogy	—	50,307	30,000	20,307	247	12,150	3,000=6ft of gallery lngth per annum.	600	40	24,000
Meteorites	294									
† 3 Petrology . . .	110	—	—	—	—	—	—	—	—	—
Mineralogical Studies										
* 4 Teratology . .	—	—	—	—	—	—	—	—	—	—
E 2 Geographical Distribution	—	—	—	—	—	—	—	—	—	—
* 5 Library	—	—	—	—	—	—	—	100	50	5,000
Total length of galleries								7,400		291,500
E 3 Elementary Collections, introductory to the General Collections	—	—	—	—	—	—	—	150	150	22,500
E 4 Lecture Theatre .	—	—	—	—	—	—	—	70	70	4,900
R, Apartments for Guardian, Fireman and Doorkeepers	—	—	—	—	—	—	—	80	40	3,200
							Total . .	7,700	—	= 322,100

* 1, OSTEOLOGICAL specimens would be distributed in the vertebrate classes in the following manner: Additional length of 550 feet to MAMMALIAN GALLERY; 500 feet (with eggs, nests, etc.) to AVIAN GALLERY, and 250 feet between the REPTILIAN and PISCEAN GALLERIES. * 2, FOSSIL ANIMALS and (* 3) PLANTS would be distributed over the RECENT zoological and botanical series, and a STRATAGRAPHICAL COLLECTION that would have to be established. * 4, Teratological Specimens would be distributed over the Animal, Vegetable, and Mineral collections, and are included in the estimate for space. * 5, THE LIBRARY, or at least that portion embracing special descriptive natural history, should be distributed in the studies attached to each class gallery.

† 1, Models, Specimens, etc., illustrating the generative functions, embryological, developmental, and parthenogenetic phases of the several groups, to the extent of at least 500 typical examples, should be distributed in the galleries or studies, as an essential portion of any modern Natural History Museum. † 2 and 3 are essential branches of a complete natural history series, but as yet our National Museum does not include stratagraphical groups of fossils, or a collection of rock specimens.

B 1, 2, 3, comprising British Natural History, together.

E 1 and 2, illustrating the geographical distribution of the varieties of the human race, in connection with the most characteristic animals, plants, and representative species of the various geographical regions, might judiciously be associated with the Elementary Series, E 3, in the Rotunda of Typical Natural History, as introductory to the general Representative Collections—which building should also contain the Lecture Theatre (E 4) and the Guardian's Residences (R).

MINING AND QUARRYING.—XXIII.

BY GEORGE GLADSTONE, F.C.S.

ZINC.

ORES—ASSAYING—CALCINING—SMELTING—PURIFYING—SPELTER—SHEET-ZINC—VARIOUS USES.

THE ores of zinc which are to be found within the limits of the British Isles do not equal in importance those of some other foreign countries; and accordingly, although the various applications of zinc have greatly increased within the last few decades of years, the home production of the metal has had to struggle against the superior advantages of some of the foreign sources of supply.

Almost every one must be familiar with the Vieille Montagne zinc, which comes here from large works of that name in Belgium. Silesia also used to furnish us with great quantities, and latterly Spain has contributed her rich stores of this metal, while the United States of America are ready to furnish any quantity of the oxide that may be desired.

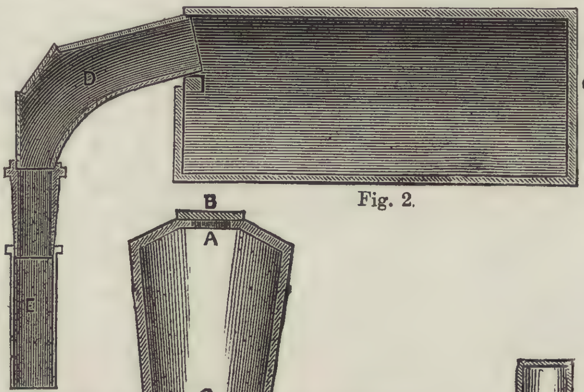


Fig. 2.

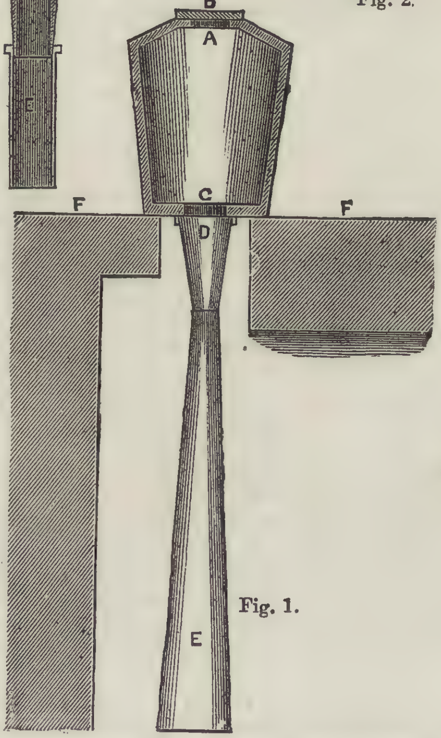


Fig. 1.

Fig. 3.

There are only four descriptions of ore which are of any commercial importance. The first of these, so far at least as England is concerned, is the sulphide, ZnS, commonly called blende on account of its brilliance, or "black-jack" by the miners because of the intense blackness of the crystals. Theoretically it should contain 67 per cent. of the metal, but it is usually associated with a large per-centage of sulphide of iron, and other minerals, to which its black colour is due. It occurs principally in the carboniferous limestone, in the same veins as the sulphide of lead. The two are therefore often mined simultaneously, the blende serving as a subsidiary source of income to the lead mine. The largest home supplies are derived at present from the lead districts of North Wales and of the Isle of Man, but it is also raised in Cornwall, Devon, Derbyshire, Northumberland, and some other places.

Next in importance comes the carbonate, called "calamine" by mineralogists. This used to be in great demand by the makers of brass on the old principle described in the last article; but it is now a comparatively scarce mineral in England, and the competition of the foreign metal has seriously interfered with the working of it. This is the prevailing ore at most of the great Continental works.

Silicate of zinc is very often found associated with the carbonate, and it is considered to produce a very pure metal.

The oxide of zinc occurs in large quantities in the State of New Jersey, U.S., where it is used in the preparation of zinc paint.

When the ore is brought to "grass" it has to be carefully separated from the lead ore with which it is generally mixed, and the two present a sufficiently great difference in outward appearance to enable this to be done at a glance without any fear of mistake.

The blende being thus made into parcels, an assay is taken to ascertain the proportion of metal in the ore. This may be done in various ways. One plan is to precipitate the zinc as a sulphide from an ammoniacal solution, by the addition of a solution of sulphide of sodium of known strength; and the quantity of sulphide of sodium required for the purpose will thus give by calculation the quantity of metallic zinc which was in the solution; and the weight of ore from which this was originally made being also known, the per-centage of metal is easily ascertained. The presence of silver, lead, or cadmium, small quantities of which are often found in the blende, will not affect the result.

Another plan, which cannot be so thoroughly relied upon for exactness, though sufficiently so for most practical purposes, consists in dissolving out the oxide of zinc from a given quantity of calcined blende, by means of carbonate of ammonia, and then ascertaining the loss in weight, which will represent the amount of the oxide contained in the sample taken.

The per-centage of metal may also be ascertained by the loss in weight in fusing the calcined ore in a crucible with charcoal. A certain quantity of the ore is mixed with about one-fourth its weight of charcoal powder, of a quality which will be known to leave a certain weight of ash; and after exposure to a high temperature for about half an hour, the contents will on re-weighing, and making allowance for the ash left from the charcoal, be found to have lost weight; this will represent the amount of oxide of zinc which has been volatilised.

We now come to the processes of reducing the ore to the metallic state. They are generally known as the English, the Silesian, and the Belgian; but they are all one in principle, the differences consisting in the mechanical arrangement. The metal in all cases is distilled out in retorts, of one pattern and arrangement or another.

Preparatory to this, however, the ores are crushed between iron rollers, or ground fine, and washed, so as to separate all earthy matters. Then they are calcined in reverberatory furnaces for about twenty-four hours: the most approved plan of doing this is to have a double-bedded calciner, the one overlying the other, and this may be heated with the waste gases from the reduction furnace. The ore is first dried on the top of the calciner, then allowed to fall through an opening into the upper bed, where it remains from six to twelve hours according to the nature of the ore, during which time it should be well rabbled; after this it is raked through a hole into the lower level, where the heat is much greater, and where the ore remains for a similar period. As soon as the first charge passes forward to the lower bed, a fresh supply is introduced into the upper, so that a constant succession is kept up, and all the heat of the furnace is thus utilised. When blende is the ore used, twenty-four hours is about the time occupied by this process, but calamine will not take more than about one-half.

The next step is the reduction of the metal. For this purpose a series of retorts and receivers are required, and a furnace.

In all the processes referred to, the retorts are made of refractory clay, and are made at the reduction works; but they vary considerably in form. Fig. 1 is a section of the English model, Fig. 2 of the Silesian, and Fig. 3 of the Belgian. The former is a circular pot with an opening, A, in the top, for putting in the charge, covered with a lid, B; and another opening, C, at

the bottom, for the exit of the metallic fumes which pass through the pipes D and E into a receiving trough, and condense during the passage. The second is a long narrow chest, flat below and rounded above, with only one opening for all purposes, the pipes D and E for carrying off the fumes being fitted in after the charge is introduced. The Belgian consists of a cylinder of clay, like a drain-pipe, closed altogether at one end, and partially so at the other. The appendages D and E correspond to those similarly marked in the two other diagrams.

In respect of size they differ quite as greatly as they do in form; and this renders a very different furnace arrangement necessary in each case, so as to ensure a proper economy of fuel. An English pot contains a charge of about 350 lb. of ore, a Silesian retort about 70 lb., and a Belgian about 25 lb. It must not be supposed from their names that the former is only used in England, and the others in their respective countries; for pots made in all these countries may be found standing side by side in the same works.

The retorts are made of fire-clay, well worked up with the remains of old pots ground fine, and when sufficiently kneaded the clay is built up on the inside of the mould, and well beaten to prevent the occurrence of any cracks or air-holes, just as in making the pots for the glass works; and when complete they are carefully dried and annealed prior to use.

The English furnace is in the form of a kiln, and is made to contain six pots. These stand on the floor of the kiln, F F (Fig. 1), immediately over a corresponding number of openings which lead to vaulted chambers below, in which (being kept cool) the zinc readily condenses. The pot being in position, and the short pipe D being fixed on, it is now ready for charging. Some billets of wood are placed over the hole at the bottom, upon them a quantity of coke, and then the calcined blende in four separate parcels, alternating with layers of coke. The lid B is then put on and luted down, and the furnace is heated. Presently a brownish-coloured flame issues from the pipe D, which afterwards changes to a light blue, and which is indicative of the zinc commencing to come over, and of the time having arrived for fixing on the long pipe E, to prevent its becoming dissipated. Below this a tray is put, into which the condensed zinc falls in a gentle metallic shower. When the drops succeed each other very slowly, it would involve too great a waste of fuel to continue the operation. The whole is usually extracted in something less than three days from the time of charging, and the result, if an average quality of blende is used, will be about 150 lb. of metal from each of the six pots.

The Silesian furnace is square, with a long narrow fire-grate running through the middle of it, below the level of the floor; with the furnace-door at one end, and the chimney at the other. On each side of the grate, with their backs, G, towards the fire, stands a row of twelve of the retorts shown in Fig. 2, and the flues are so arranged that the fire passes all round and over the twenty-four retorts before entering the chimney-stack; the whole of the retort, down to the junction of the nozzle D with the condenser E, being enclosed within the furnace. In this case each charge is worked off in twenty-four hours. The first four are occupied in raking out the remains of the last, and in re-charging the retorts, during which time the fire is allowed to slacken; it is then got up to nearly a white heat, and maintained at this until the operation is about over. The volatilised zinc passes through the nozzle and the condensing tube into a receiver below, as already described. Each retort yields on an average about 24 lb. of metal.

The Belgian furnace is again quite differently arranged. As many sometimes as ninety of the little retorts (Fig. 3) are arranged in rows one above another, the front of the furnace being furnished with a series of shelves, with a corresponding notch at the back for them to rest upon; the fire-grate is immediately below, and the heated gases pass between all these rows of retorts before reaching the flue at the top which leads to the chimney. The spaces between the retorts in front are filled up with clay, to prevent the escape of the heat in that direction; the back of the furnace is solid. They are often built back to back, as a matter of economy. The retorts are charged every twelve hours, and the lower ones, being exposed to a much greater heat than the upper rows, receive a much larger charge than the latter. The zinc is not only condensed, but also collected in the receiver E (Fig. 3), the end of which is nearly closed for that purpose.

The rough zinc obtained by these several processes has to be re-melted, to be purified and made into cakes. This is done in iron pots; the zinc is well stirred, and the scum which floats upon the surface is carefully skimmed off, after which the metal is poured into moulds. If it should contain any lead, it is allowed to stand for some little time until it cools down to near the solidifying point of zinc, when the lead will collect at the bottom of the pot.

Cadmium is very generally to be found in the rough zinc, but it is easily separated, as it is a highly volatile metal; and all that is necessary, therefore, is to keep the zinc in a molten state for a sufficiently long time in an open furnace.

Metallic zinc in cakes or ingots is known commercially under the name of spelter, and as such it is largely exported to India and elsewhere.

It was only about the beginning of the present century that it was found possible to roll zinc into sheets, because it is highly crystalline, and only possesses a slight degree of ductility. It is brittle under the hammer both at the ordinary temperature and at 400° Fahrenheit, but between the boiling-point of water and 300° Fahrenheit it is sufficiently tenacious to be rolled out into sheet or drawn into wire. This discovery was of no little importance, as the value of zinc is so moderate as compared with the other metals which could be treated in the same way. Accordingly, sheet zinc is now very largely used for roofing, and making gutters, spouts, and pipes; and it has this great advantage over copper, that the slight oxidation which soon takes place over the surface perfectly protects the metal below from the atmospheric influences; so that as far as exposure to the weather is concerned, it will remain unchanged for an almost indefinite period. It has also the advantage over lead in that, being harder, a much thinner sheet can be used; and that the oxide does not cause water that is exposed to its influence to become poisonous. For these reasons many domestic utensils are made of zinc, though it cannot be conveniently used for any purpose in which it might be subject to high temperatures. Although the price of the material and cost of fixing is more than double that of the coarse asphalte felting used for roofing purposes, it is far cheaper in the end where durability is required, as the metal will not require renewal for many years, and the constant application of tar which is required to keep the felting water-tight is altogether dispensed with.

The valuable applications of zinc as a constituent of useful alloys have already been described under the headings of iron and brass; but there are several other minor uses which must not be overlooked.

Both the oxide and the sulphate are used in medicine; the oxide is also used sometimes as a substitute for a lead salt in the manufacture of crystal glass, and in colouring pottery.

It is also employed in the place of lead in the manufacture of painters' colours, and it is much to be recommended on account of its harmless character. The oxide of zinc is prepared in America for this purpose on a very extensive scale, by reducing the ore in reverberatory furnaces, and burning the zinc vapour which is evolved, the light fumes from which are carried into a chamber made of canvas which is kept moist, and on the inner surface of which they are condensed in the state of oxide.

As pure zinc melts at about 800° Fahrenheit, and is very limpid, it forms a convenient material for making large castings; the edges and other fine parts will come out very sharp from the mould, so that but little subsequent trimming up will be necessary; and by artificially bronzing it, an agreeable colour can be given to its surface.

There is one very important application of zinc which has been reserved to the last, because it is of a totally different character from the rest—viz., its use in electricity. It is the most electrically positive of all the metals that can be conveniently used, and accordingly it finds its place in every form of galvanic battery that has been brought into practical use, from the original voltaic pile down to the very extensive and elaborate apparatus described in the first paper on the "Electric Telegraph." For the negative pole different inventors have employed various metals, such as copper, silver, platinum, etc., but in every case zinc is adopted as the positive. The metal for this purpose should be as pure as possible, and well rolled, so as to be compact and free from holes, which would tend to an irregular consumption of the metal, and render necessary a more frequent renewal of the plates.

OPTICAL INSTRUMENTS.—XX.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

Photogenic Arrangements.—Before leaving the subject of magnesium and zinc lights, it may be as well to put on record, as suggestive to experimenters, certain chemical means of generating intense lights, which, however, as yet have only been used as lecture-room experiments, and not as practical applications. Thus, by digesting metallic zinc in iodide of ethyl, we obtain a volatile liquid which takes fire spontaneously in the air, and is known to chemists under the name of "zinc-ethyl." It can be distilled in an atmosphere of hydrogen, and if this gas be made to pass through the liquid it will carry off some of the zinc-ethyl, and when ignited will burn with a magnificent white flame. It is probable that ordinary illuminating gas would answer as well as hydrogen for this experiment. The light produced in this way can be employed to take photographs, but its actinic properties are not equal to the effects produced by burning magnesium. Of the same nature is *magnesium ethyle.* Dr. Lyon Playfair made the suggestion to me of dissolving magnesium ethyle in petroleum, and burning it in a suitable jet. As with magnesium and zinc ribbon, white clouds of magnesia would be produced during combustion. Then we have the *chloro-chromic light.* This is produced by passing dry hydrogen, or carburetted hydrogen, through the vapour of chloro-chromic acid, and burning the impregnated gas with a steatite burner. Chloro-chromic acid is easily prepared thus:—Fuse 17 parts of bichromate of potash with 10 parts of common salt, and pour out the mixture upon a slab of cold marble. Break into lumps, and distil with about 40 parts, by weight, of sulphuric acid. Take care that the vapour given off is properly disposed of, and not inhaled, as it is very irritating, though not so much so as bromine vapour. Place the resulting chloro-chromic acid in a small Woulff's bottle, or, what is better, a Woulff's arrangement made out of a capped, wide-mouthed ether bottle, in which a cork fitted with an ingress and egress tube is made to replace the glass stopper when required for use. The ingress-tube is connected with a reservoir of hydrogen, under a sufficient pressure, by india-rubber tubing, in the course of which a chloride of calcium drying-tube is inserted. The ingress-tube should be inserted so as just to reach the surface of the chloro-chromic acid—not deeply inserted in the liquid, to bubble through it, but simply to sweep away its fumes. The egress-tube is fitted with a steatite fish-tail burner, or small incorrodible argand burner, as the fumes attack metal. The chloro-chromised hydrogen burns with an intense white light, which gives off clouds of oxide of chromium; it cannot be burnt for long unless connected with an up-draught. Dr. Monckhoven speaks of burning this flame "in a current of oxygen; oxide of chromium is produced at a very high temperature, and at the same time a flame of such extraordinary chemical power that chloride of silver paper held at a distance of eight inches blackens sensibly in thirty seconds, *or about as quickly as in full daylight.*"* Chloride of titanium treated in the same manner gives a blue flame of extraordinary chemical power. In 1863 I exhibited, at a lecture at the Society of Arts, an intensely brilliant and actinic flame, by passing carburetted hydrogen through a long column of bisulphide of carbon vapour, burnt in a flat argand burner four inches wide. Like those previously described, the fumes given off (in this case those of sulphur) were the drawback to its utilisation. As a lecture-table experiment it is very striking.

Bude Light.—In this arrangement oxygen is introduced into the centre of an argand burner, thus replacing the ordinary current of atmospheric air. The argand burner may be supplied with oil or house gas, and the result is a brighter light than is obtained under ordinary circumstances. It is believed that the "oxy-hydric light" recently exhibited at the Crystal Palace is a modification of the bude light arrangement devised and named by Goldsworthy Gurney. Gurney's arrangement also embraced the system of concentric rings of house gas, with strong up-draughts of air brought into contact with each small jet of gas, by means of cones of glass and chimneys, disposed to the best advantage by careful experiment, and large metallic reflectors placed over the chimneys just above the brilliant zone of white light thus produced, so as to cast it downwards. The term "bude light" is, however, usually applied to the first arrangement, where oxygen is made to replace a simple supply of atmospheric air.

Argand Lamps.—In the burner invented by Argand a column of air is introduced into the centre of a lamp flame, and an up-draught created by means of a chimney, the length of which is adjusted to secure perfect combustion. This principle of burner may be arranged to consume gas or liquid. If spirit or oil is consumed, a wick becomes necessary. Wicked lamps may be arranged under two heads—"Suction Lamps" and "Pressure Lamps." Suction lamps may again be divided into two groups, viz., "Simple Suction Lamps," wherein the wick descends to the bottom of a simple reservoir, and consequently the capillary action of the wick has to raise the liquid to the flame from an ever varying level; and "Fountain Lamps," wherein the spirit or oil is raised from a constant level by means of a hydrostatic arrangement of the reservoir. "Pressure Lamps" force the oil (for which this form of lamp is only suitable) by means of a pump, driven by clockwork in Carcel's lamp, and by a rack and coiled spring* in the Moderator lamp, to the top of the wick and the verge of the flame in greater quantity than can be burnt, and so cause a constant overflow into the reservoir beneath, which prevents the rapid charring of the wick, and less heat being conducted away from the flame by the metal-work. To increase the liquidity of oil, the reservoir, in the form of a ring, has been placed around and above the burner, as in Parker's and the Sanumbra lamp. To bring the air in more immediate contact with the *exterior* surface of the flame, a thin metal cone has been employed. To throw the air into closer contact with the inner edge of the flame, an inner tube has been inserted in the centre of the argand burner. When a great body of light is required, as for lighthouse purposes, double concentric wicks have been employed. To avoid danger when light hydro-carbon oils are used, a non-conductor of heat—such as boxwood—has been inserted between the metal-work of the burner and the inflammable spirit, as in Young's Vesta Lamp. To prevent an overflow of more than a small portion of liquid in case of a lamp being overturned, an inner wall has been inserted in Silber's simple suction lamp, so as to isolate the mass of petroleum from the wick.

The general principles of construction of argand burners for consuming liquids may be thus summarised under these four heads:—1. A constant and steady supply of oil or spirit at the exact rate of consumption. 2. The means of adjusting the flame to the point of perfect combustion. 3. The adjustment of the interior and exterior currents of air upon the wick, to secure perfect combustion, according to the nature of the substance and the size of the burner employed. 4. The disposition of the reservoir, so that its shape or position shall not interfere with the proper distribution of the light emitted.

Having summarised the general principles of construction of argand burners, I purpose describing a type of each form suitable for hydro-carbon spirit, oil, solid paraffine, and gas.

Hydro-carbon Argand Lamps.—Volatile paraffine oil with a specific gravity of 0·700 to 0·865, heavy paraffine oil with a specific gravity of 0·865 to 0·900, and solid paraffine, the so-called paraffine wax, with a specific gravity of 0·900 to 0·930, the products of the fractional distillation of the crude liquid and tarry matters which come over in the primary distillation of peat turf and bituminous schists, of which the Boghead schist gives the richest yield, and petroleum, the purified natural product of the American coal measures of Ohio and Pennsylvania, give lights of great intensity when burnt in properly constructed lamps. The photogenic oils produced from various sources, and at different temperatures, that figure under different names in the market, though varying somewhat as to chemical constitution, have their specific gravity and boiling-points so close to each other that it is a matter of great difficulty to isolate them, to allow of an examination of their properties. They are tolerably equal as to their photometric value, though I am not aware that any exact photometric comparison has yet been made, or at any rate published.

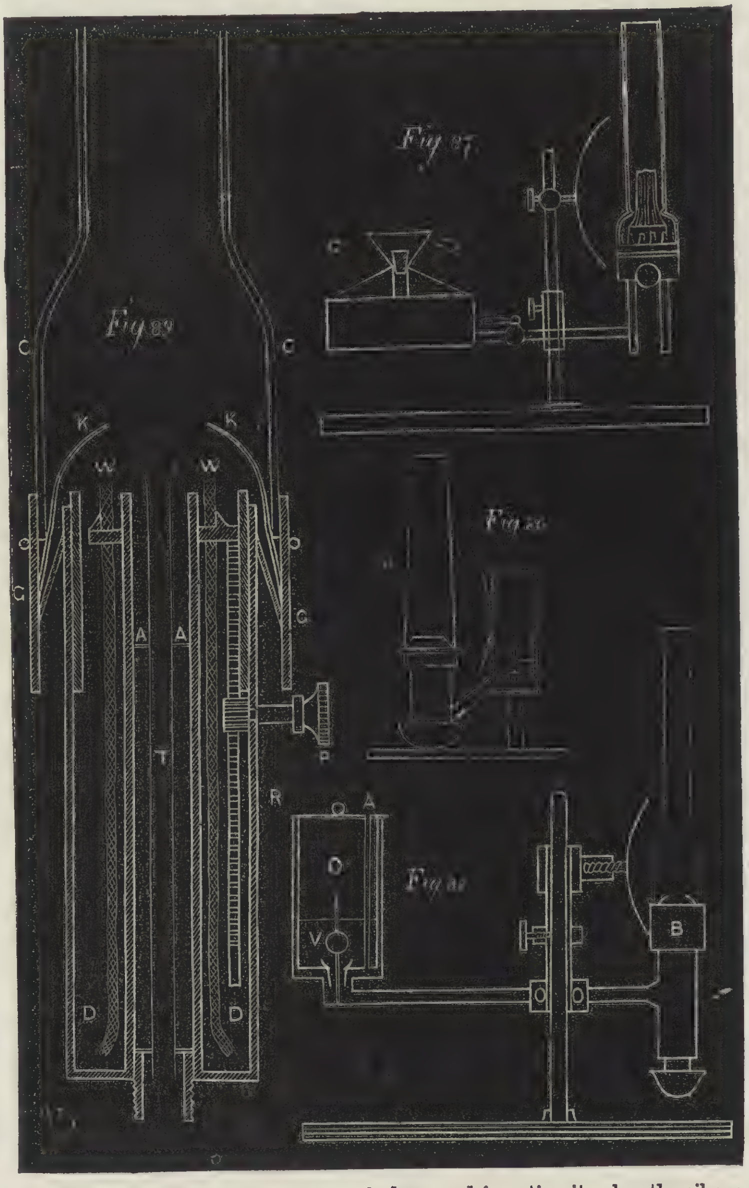
Though extensively used in America, and the countries of Northern Europe, a strong prejudice still exists in England against the use of paraffine and petroleum oils. This arises

* *Photographic Society's Journal*, p. 166. December 18th, 1869.

* This is termed, from its inventor, a "Priest-pump."

chiefly from a dread of the assumed explosive qualities of all mineral oils, and in a less degree on the score of the unpleasant odour given off more or less by these liquids. By a selection of suitable samples, and properly constructed lamps, these drawbacks to their use may be surmounted. Danger can only arise from the employment of mineral oils which ignite at low temperatures, as suitable samples may have a match placed in contact with their surface without igniting, and, if spilt upon a table and floor, would not become dangerous till vaporised by the heat of the room. Danger may arise from improper storage, for if left open to the atmosphere of a small room any vapour arising would mix with the air and form an explosive compound. The sale of dangerous samples—viz., mineral oils having a low boiling-point, the vapour of which inflames below a temperature of 90° Fahrenheit—is forbidden by the Act of Parliament of 1868, except under proper restrictions; nevertheless, care should be exercised when purchasing paraffine oil, as unscrupulous or careless dealers may be met with.* The unpleasant smell is mainly due to imperfectly constructed lamps that do not effect perfect combustion, or to careless trimming and neglect in wiping the oil from the metal burner or reservoir. Again, it may arise from the wick being turned down too low, instead of being adjusted to what may be termed the standard point of illumination of any given lamp, when the flame would neither be too high nor too low for effecting perfect combustion of the material supplied to the wick.

After trying every kind of hydro-carbon oil that has a character for intensity of light for scientific purposes, I give the preference to refined petroleum having a specific gravity of 0·695, and a boiling-point about 340° Fahrenheit, as it is almost inodorous, and does not give off that greasy kind of vapour that all paraffine oils generate when a lamp is shut up in a lantern for some days, and which bedews the metal-work, saturates the wooden parts, and creates a most unbearable stink when the lamp is again lighted—a smell which is rendered still more unpleasant if, for the purpose of increasing the density of the flame, one ounce of camphor is added to a quart of paraffine, an odour which cannot be covered by the addition of any of the scented essential oils.



Hydro-carbon lamps are used for magic lanterns, photographic self-registering meteorological apparatus, etc. The simplest forms are those of suction lamps, shown in Figs. 86, 87. In Fig. 87 the reservoir, instead of being immediately beneath the wick, is placed behind, so that the mineral oil may not be heated, as the reservoir thus arranged can be placed outside the lantern. It will be observed that in an arrangement of this kind the liquid must ever be sinking to a lower level.

Fig. 88 represents one of the most perfect arrangements, the burner being shown in detail in Fig. 89.

The lamp is adjustable on a rod like that previously described under the head of my "convertible jet." The burner, B, is supplied by a "fountain reservoir," O, the two parts being connected by a brass tube that passes through a boss in the adjusting tube. The reservoir, O, consists of a metal cylinder that has an opening at its lower end, which can be closed by a ball-valve, V. This fits inside an outer cylinder, that is attached to the connecting tube, and acts the part of a funnel to carry the oil from O to the burner B. The reservoir is filled by removing it from the lamp and inverting it, when the oil can be poured into the open mouth at V. The wire that passes through the ball of the valve is then seized between finger and thumb, and pulled up into its socket, when the reservoir is turned over and quickly inserted into the outer cylinder; when the end of the wire of the ball-valve touches the bottom of the tube, the ball is raised, which allows the oil to flow out, an equal quantity of air at the same time rising through the oil to the top of the reservoir, O. As the oil is consumed it sinks below the aperture of the reservoir, when another portion of air enters, and again ejects an equal quantity of oil, which of course finds its level in the receiver of the burner, B, and so, by the automatic action of this "bird fountain" reservoir, a constant level is maintained. To secure a current of air to

* In the Schedule to the "Petroleum Act Amendment" of 1868 "Directions for applying the Flashing Test to Samples of Petroleum Oil" are given, and the prescribed apparatus described; but I may state that it has not proved efficient, and an improved instrument will probably be authorised under a new Act of Amendment, wherein a covered petroleum pan will replace the present open arrangement, which allows the vapour as formed to be wafted away by currents of air passing over the exposed surface of petroleum, and so causing the Parliamentary test to be very unreliable. Other improvements will allow of the absolute temperature of the petroleum to be more accurately determined.

the immediate neighbourhood of the valve, an air-tube, A, passes from the outer to the inner end of the reservoir, though this may be dispensed with, if the reservoir is made to fit the outer cylinder loosely, to allow air to pass between them to the mouth of the valve at V.

The burner is shown in section in Fig. 89. W W represents the cylindrical wick supported in the cylindrical wick-tube, D D, and adjustable by means of the rack-and-pinion arrangement, R P. A small tube, T, is supported in the central air-way by three pins, A A, placed at equal distances on its outer side. The object of this tube is to throw the up-current of air into more immediate contact with the *inner* side of the wick. G G represents the gallery that supports the glass chimney, C C, and a thin metallic dome or cone, K K, that draws the air into more immediate contact with the *outer* side of the wick. The height of the chimney is a very important point in construction, for on that depends the adjustment of the up-draught in such quantity and at such a rate as to secure perfect combustion, for, according to the proportion of carbon contained in the mineral oils, so they require a greater or less supply of air for their proper oxygenation.

If through inattention on this score the volatilised oil is only partially burnt, there will be wasteful consumption of the liquid. The unpleasant odour often noticeable with paraffine oil is frequently due to the same cause. The diameter and height of the chimney influence the size, height, and form of the flame, sometimes contracting it into a cone, and then reducing its illuminating power. With the self-same burner four times the amount of light may be produced, when fitted with a series of unsuitable and suitable chimneys. The point of constant level for the liquid below the top of the wick is a matter of constructive importance. As previously stated, when heavy vegetable oils, such as colza or rape-seed oil, are burnt, the lamp is arranged to bring a constant and overflowing supply to the verge of the flame. Not so with mineral oils: with these the level may be some two or three inches below the top of the wick, as the object in this case is to vaporise the liquid by means of the hot metal of the wick-holder or receiver, and so convey it to the flame in an almost gaseous condition, heated nearly to the point of ignition before it comes in contact with the air that is impinged on the inner and outer side of that flame. The importance of this detail of construction may be judged of when it has been found that by raising the level of the oil an inch or more above the proper point, a decrease of from 30 to 50 per cent. in illuminating power has ensued. The wick best suited for petroleum is a rather loosely plaited cotton; this should be most carefully cut the first time of burning, after which it is better to rub off the charred portion with the tip of the forefinger, then cut off any projecting fibres with a very sharp pair of shield scissors, specially made for lamp-trimming. Petroleum possesses the advantage over ordinary oil that the wick chars very slowly, and consequently gives the standard amount of light for a much longer period of combustion. Like the Carcel lamp, it might be used as a standard source of light for determining the illuminating power of coal-gas and other burners in photometric testing. The pinion P, that raises or depresses the wick W, by its action on the racked support R, should be inserted in the wick-tube a little above the level of the reservoir, to prevent any leakage of that very mobile liquid.

In a paper read before the Society of Arts, Dec. 21st, 1870, Mr. A. M. Silber gave in the following tables the results of some interesting experiments conducted by Mr. Valentine at the College of Chemistry, on burners of the usual construction, and those made according to the principles previously described:—

TABLE I.—SHOWING ILLUMINATING POWER OF ORIGINAL ARGAND BURNERS, CONSUMING COLZA AND PETROLEUM OIL.

DESCRIPTION OF LAMP. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet, for one week's consumption of 42 hours.	Proportional cost of gas and oil.
Colza Oil Lights.				s. d.	d.	
Lamp 1, consuming colza oil from an argand burner, wick ⅞ to 15/16 of an inch	11·81	—	1,203	2 9⅛	—	—
Lamp 2, with imperfect chimney, wick 1¼ . . .	3·98	—	532	1 2⅔	—	—
Ditto, with differently constructed chimney . .	15·01	5	1,775	4 1	9·45	1 : 5·2
Petroleum Oil Lights, as originally constructed.						
No. 1 Burner, size of wick ⅞ to 15/16 of an inch . .	15·67	5·22	864	0 11·8	9·86	1 : 1·21
Do. do. do.	15·47	5·15	787	0 10·7	9·73	1 : 1·11
No. 2 Burner, size of wick same (of French construction)	14·93	4·98	818	0 11·1	9·4	1 : 1·18
No. 3 Burner, size of wick 1¼ of an inch . . .	17·01	5·67	818	0 11·1	10·7	1 : 1·04
No. 4 Burner, size of wick 1½ of an inch . . .	33·85	—	2,145	2 5	—	—
No. 5 Burner, size of wick 1¾ of an inch . . .	38·32	—	3,433	3 10⅔	—	—

TABLE II.—SHOWING ILLUMINATING POWER OF ALTERED ARGAND BURNERS, CONSUMING PETROLEUM OIL, AS COMPARED WITH ORIGINAL BURNERS.

DESCRIPTION OF LAMP. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet for one week's consumption of 42 hours.	Proportional cost of gas and oil.
				s. d.	s. d.	
No. 1A Burner, wick	14	4·66	602	0 8·18	0 8·8	1 : 0·93
No. 1 Burner (original) wick ⅞ to 15/16	15·67	5·22	864	0 11·8	0 9·86	1 : 1·21
Do. 2nd experiment	15·47	5·15	787	0 10·7	0 9·73	1 : 1·11
Do. (altered)	23·24	7·74	795	2 10·8	1 2·63	1 : 0·738
No. 2 Burner (original), same size as No. 1 (of French construction)	14·93	4·98	818	0 11·1	0 9·4	1 : 1·18
Do. (altered)	21·52	7·17	788	0 10·7	1 1·55	1 : 0·79
No. 3 Burner (original), wick 1¼	17·01	5·67	818	0 11·1	0 10·7	1 : 1·04
Do. (altered)	28·0	9·33	1,102	1 3	1 5·6	1 : ·85
No. 4 Burner (original), wick 1½	33·85	—	2,145	—	—	—
Do. (altered)	46·5	—	2,008	—	—	—
No. 5 Burner (original) wick 1¾	38·32	—	3,433	—	—	—
Do. (altered)	50	—	1,965	—	—	—

From the last column in Table II. we find that for No. 1 Burner (altered) the oil is 35 per cent. cheaper than gas, while for No. 2 Burner (altered) it is 27 per cent. cheaper.

It is interesting to note that the larger argands give, proportionally, less light than the smaller-sized burners—a ratio which is the reverse of that observed in the case of argand gas burners. The central air-deflecting tube exerts considerable influence in correcting this shortcoming in the burners of larger size. The larger burners also consume, proportionally, more petroleum than the smaller burners. This is probably due to the passing of some portion of the oil in the form of incompletely burnt or unburnt vapour through the mantle of the flame.

PHOTOGRAPHY.—X.

By J. C. Leake.

PRINTING IN CARBON.

For many years photographers have been steadily working in order to produce a process which should remove the one great objection to ordinary silver-printing—namely, its want of permanence. Although it is true that prints produced by this process need not of necessity fade, yet it has been proved in practice that it could not be absolutely trusted as to permanence, one print out of a large batch perhaps fading in the course of a few months, while the remainder continued unaltered for years. This want of certainty as to the durability of photographs was of necessity a great drawback to the art, especially where it was applied to purposes of book-illustration, the reproduction of works of art or valuable manuscripts, and was, of course, more important as photographs increased in dimension, and became proportionately more expensive. To such an extent had this difficulty been felt that the sale of ordinary photographs of large sizes had perceptibly diminished, and but for the invention of the system of printing in carbon, would probably have ceased altogether; few persons caring to purchase a picture costing perhaps some pounds, to which was attached a probability of loss at an early period. Hence it had become important, if it was necessary to save the art, especially in its higher branches, to devise some method of obtaining prints which could be relied upon for permanence, and this has happily been most effectually accomplished.

Like all other branches of photography, the perfecting of a carbon process has been the work of considerable time; and many persons have contributed improvements of importance, the latest being those of Mr. J. R. Johnson, whose process, termed the autotype, may be considered as nearly perfection as can be expected for many years to come. Of course there are many processes which vary in detail; but as that of Mr. Johnson is by far the most simple, considering the perfection of the result, as well as from the fact that it offers unusual facilities to the amateur, we shall in this paper confine our remarks to this alone, referring those who may wish for further information upon this matter to one or more of the text-books published upon the subject, especially to Mr. G. W. Simpson's "Printing in Pigments."

Before proceeding to describe the manipulations required in the practice of carbon-printing, it will be well to explain in outline the principles upon which it is founded, and which differ so much from those of the ordinary silver-printing that the operator must abandon these latter at the outset. It has been known for many years that gelatine, after having been impregnated with bichromate of potash, is to a certain extent sensitive to the action of light. This sensitiveness is not manifested in the same way as upon the ordinary silver-sensitised paper, by a darkening of the film, but by the fact that the portion upon which the light has acted becomes insoluble, while that which has been protected from this action remains, like ordinary gelatine, freely soluble in warm water. It stands to reason, therefore, that if a film of gelatine, sensitised by bichromate of potash, be placed under a negative and exposed to light, some portions will be rendered insoluble, while others may be removed by washing in warm water, the result being an image in varying thicknesses of the film; the highest lights, which have been entirely protected, being removed altogether. This, however, would be simply an image in relief, without light and shade, which, although useful in some processes, would not in itself form a picture. In order to form a picture in light and shade, however, all that is necessary is to add to this gelatine some colouring matter, which may be retained by the film in its varying thicknesses; when, of course, those portions which are the thickest will represent the darker portions of the picture, while the lighter parts will be altogether dissolved out, all the intermediate shades being duly represented by the various quantities of pigment retained by the film. This is precisely what is effected in Mr. Johnson's process. A film of gelatine, containing a suitable pigment, is spread upon paper, and is sensitised upon a bath of bichromate of potash. When dry, this pigmented paper is placed under a negative, and exposed to the action of light. Upon removal from the printing-frame the print is attached to a suitable support, during the removal of the unaltered gelatine and pigment. A properly prepared paper is then secured to the film, and this with the film is, when dry, removed from the supporting surface, when the picture is complete and ready for mounting.

One of the chief obstacles to the common adoption of the carbon-printing process, up to this time, has been the difficulty of preparing the layer of carbonised gelatine, which must, of course, be most carefully effected. This, however, need no longer stand in the way, as the Autotype Company are prepared to supply this tissue ready for use at a far lower cost than it could be made by the operator. The pigmented paper, as supplied, consists of a layer of gelatine spread upon paper, and it may be obtained of varying tints to suit the subject of the photograph. The gelatined side of the paper will be found to closely resemble the material known as American leather-cloth, having a dark colour and glossy surface. As supplied, this tissue is not sensitive to light, and in this respect it resembles ordinary albumenised paper. It is prepared in long rolls, and much larger sheets may be obtained than those of albumenised paper. For use it should be cut to the required size before sensitising.

The sensitising solution is prepared by dissolving in common water bichromate of potash, in the proportion of twenty grains of the salt to each ounce of water. A sufficient quantity of this solution is to be placed in a flat dish, when the sheets of prepared paper may be immersed one at a time, taking the utmost care to avoid the formation of air-bubbles. Each sheet should be turned over several times, to ensure a uniform action of the solution, and several sheets may be immersed at the same time. After one or two minutes have elapsed, the whole of the sheets may be turned over in the solution, and the one first inserted then removed and suspended to dry. It is one of the great advantages of the tissue prepared by Mr. Johnson, that this drying may be accelerated by heat, while in many of those heretofore prepared the application of heat simply rendered the film more soluble, and the greatest difficulty was experienced in keeping the pigmented gelatine upon the paper at all, the whole coming off in a sludgy mess, and leaving the paper quite bare.

This difficulty is not likely to occur when Mr. Johnson's preparation is used; but in the case of a tissue such as we have mentioned being met with, we have found that it may be remedied by *floating* the sheets upon a bichromate solution of twice the strength mentioned above, and with the gelatined surface upward, so as not to touch the solution at all, the film being allowed to receive the bichromate by absorption. In this way the most soluble tissue may be sensitised without injury to its surface, although the difficulty of drying will, of course, still remain. It need scarcely be observed that the sensitising process must be conducted in a darkened room, and as the bichromated gelatine is very much more sensitive than albumenised paper, greater precaution must be taken to exclude all light during this process, as well as during the drying; in fact, the more nearly the tissue is treated as a sensitive collodionised plate, the more perfect will be the resulting print. When the tissue is perfectly dry it will be ready for exposure to light under the negative.

Before placing the tissue upon the negative, however, a border of opaque paper should be pasted round its edges, in order to secure the margin of the print from the action of light. This is necessary in order to secure a margin of unaffected gelatine, which may serve to secure the film to the plate during the development, or rather the removal of the unaltered gelatine. This precaution is absolutely necessary, or the film will break up during the process. The sensitised tissue must, therefore, be cut of sufficient size to allow of this unaltered margin being

left, or the development cannot be conducted in safety. The exposure of the tissue to light may be made in the usual manner, but of course the progress of the print cannot be watched as in silver-printing, as there is no apparent change in the film. It may, therefore, be supposed that the production of prints by this process is merely guess-work in this particular. Such, however, is not the case, as the action of light and the consequent progress of the printing may be most accurately determined by means of the actinometer. There are several forms of this instrument, any of which may be used, but that invented by Mr. Johnson seems to possess in a high degree the advantages of simplicity and certainty. This little instrument consists of a tin box, with a small slit in the lid about an inch in length and one-fourth of that in width. The lid of this box is painted the same colour as that assumed by albumenised paper upon exposure to light. Inside this box is arranged a slip of Carrier's sensitised albumen paper. By means of a simple mechanism a portion of the paper is brought under this aperture, and when exposed to light it of course quickly darkens to the colour of the painted lid. The method of applying this to carbon-printing is extremely simple. Thus, supposing we have a very thin negative to print, the sensitive tissue being placed upon it in the pressure-frame, the whole is exposed to light in the usual manner. At the same time a portion of the sensitive paper in the actinometer is brought under the aperture in the box, and exposed side by side with the print. As soon as the paper has assumed the chocolate colour, matching with the top of the box, the print is removed from the frame; and if, upon development, the exposure is found to have been correctly timed, the negative is marked with a figure 1. Should it, however, require longer or shorter exposure, this fact is indicated by a figure in the margin. Thus, if two or three tints of the paper be required, the negative is marked with the number of changes in the actinometer, and printed accordingly. By the adoption of this method prints may be made with absolute certainty of correct exposure, provided the correct time necessary has been marked in the first instance. In this particular the carbon process is superior to the ordinary method of silver-printing, as no allowance has to be made for the somewhat irregular reduction which occurs in the fixing and toning baths usually employed.

The exposure to light having been carried out as above described, the next operation will be that of attaching the film to some suitable temporary support during the development of the image; which latter process, as we have before explained, consists of removing the unaltered gelatine and pigment. For this purpose a sheet of white ground opal glass will answer, or still better, one of the porcelain "slates" in common use. Mr. Johnson uses finely-ground plates of zinc; and, in fact, any material having a white substance, that is insoluble in water, and has a slightly roughened surface which may serve to facilitate the adhesion of the film, will answer perfectly. Before attaching the film to either of these surfaces, they should be cleaned, and rubbed over with a dilute solution of wax and resin in turpentine, the merest trace being allowed to remain. If this precaution be neglected, the film will probably adhere so closely to the plate as to defy removal, except by the destruction of the print. The plates being thus prepared, the prints should be immersed in cold water. Very shortly the curling inwards, caused by the expansion of the paper, will be succeeded by a tendency to curl outwards. At this period the print should be removed from the water, and placed gelatine-side downward upon the supporting plate, which has first also been wetted. The superfluous water should then be removed by scraping the paper down upon a plate with a scraper or "squeezer," made by securing a slip of india-rubber between two slips of wood. A little time may now be allowed in order that the print may absorb moisture, when it will be found that the proof adheres tightly to the glass or metal plate. No injury is effected by some little delay in developing the prints after they have reached this stage (say three or four hours), but they should not be allowed to become dry.

The plate with the print attached may now be immersed in water, raised to the temperature of about 100 degrees, or as warm as the hands can comfortably bear. In a few minutes the coloured gelatine will begin to ooze out at the edges of the paper, which will also show signs of detaching itself from the plate. In effecting this detachment, on no account must any force be used, as that would injure the impression. Hot water may be applied a second time if required, but this is seldom necessary; a little patience will usually be rewarded by success. After the removal of the paper, the plate holding the film should be freely rinsed with warm water, when the picture will gradually emerge from the sludgy mass of unaltered gelatine and pigment. This washing should be continued until the water flows clearly off the print, showing that the whole of the unaltered and consequently soluble gelatine has been removed. There is room for the display of some skill and tact in effecting this process of development, as a print which shows any signs of under-exposure may be often saved by removing it from the hot water and plunging it into cold water for a few minutes; afterwards continuing carefully the action with water which is only slightly warmed. On the other hand, an over-exposed print may be reduced slightly by continuing the action by means of very hot water; and the operator will find that this simple process of development is easily modified, as may be required by the condition of the print.

Should the exposure have been correctly timed, and the development properly effected, the plate with the picture upon it should be allowed to become dry before proceeding to transfer it to paper. For this purpose a properly prepared paper is required, which is supplied by the Autotype Company. The transfer process is easy if the proper paper is used, and due precautions employed in its use. One side of the transfer paper is coated with a substance which secures the perfect adhesion of the film, and which becomes soft after soaking in boiling water. The sheets should, therefore, be cut to the requisite size, and immersed in boiling water in a flat dish, until the coated surface becomes soft and pulpy. Having arrived at this condition, it may be laid wet upon the film, and smoothed down with the scraper as directed before. When the paper is thoroughly dry (and on no account before), the removal from the plate may be attempted. If started at the corners, the film will usually strip off easily, in some cases spontaneously; when, of course, the operation is complete, and the print may be mounted in the usual manner.

It frequently happens that carbon-prints present a dull surface, which is offensive to those who have been used to the high gloss of albumenised paper. In this case the defect may be remedied by applying to the surface of the finished and mounted print an encaustic paste, made by dissolving white wax in benzole to the required consistence. This paste should be applied by means of a soft linen rag, and afterwards the surface may be polished with a soft silk handkerchief. In conclusion, we may remark that, although in description this printing process may seem complicated and tedious, it is not found so in practice; and that the undoubted permanence of the proofs would well compensate for extra labour, even if this were involved, which it is not.

SILK CULTURE.—VI.

By Alexander Wallace, M.D.

CULTURE OF THE BOMBYX YAMA-MAÏ IN JAPAN.

Inasmuch as the culture of the *Bombyx Yama-Maï* in Europe is still somewhat of an experiment, notwithstanding the partial success which has attended the efforts of the Baron de Bretton and others in Europe, and as it is pursued in Japan on a definite method, it will be desirable to reproduce here the best existing evidence on this point taken from the Third Report, by Mr. Adams (of her Majesty's Legation in Japan), on Silk Culture in Japan, being an account of a tour made by him in those districts where the culture of the *Yama-Maï* is systematically carried on:—

"From Shimonita we proceeded over the Wami Pass to Owaké, in Shinshiu, and thence by the Nakasendô over the Wada Pass to Lake Suwa, from there by Shiwojiri to Matsumoto, our object being to gather information respecting the *Bombyx Yama-Maï*, or oak silkworm, which is reared in the open air not far from the latter place.

"We arrived at Matsumoto on the 16th of June. It is a castle town of over 3,000 houses, lying on the eastern side of a broad level valley of high elevation and light soil. Immediately to its north a low range of hills runs partly across the valley, so that at first sight the town appears to be situated at the north-

east corner of a plain eleven or twelve miles in length, and six or seven in breadth, surrounded by high hills. Further down, the valley re-opens, but is narrower; and above the hills, which on the western side rise abruptly from the plain, a snowy range of granite mountains is visible, dividing the province of Shinshiu from that of Hida.

"At Matsumoto we were informed that we should have to proceed twelve or fourteen miles further along the valley, in order to reach the centre of the most favoured district for the culture of the *Yama-Maï*. Accordingly, on the following morning we rode along rough roads and across swift torrents which are often impassable, till we reached the village of Furumaya on the opposite or western side of the valley. There we put up at the house of a head-man, Mokuzagemon, himself a rearer of the worm, and from him, as well as from Benjirô and Tozagemon, of the villages of Tateashi and Aragama, we gained much interesting information. Their accounts tallied entirely in substance. It appears that there are sixteen villages, the inhabitants of which form an association called the 'Matsukawa gume,' and are entirely engaged in the culture of the *Yama-Maï;* that this culture was first initiated about forty years ago, and since then had gradually taken greater dimensions, till the number of cocoons annually sold by the association alone is computed at not less than 20,000,000. The three men stated that the number which they severally reared each season averaged 170,000, 100,000, and 80,000, the price of each thousand being estimated at about four riyos (equivalent now to nearly four dollars); also that the cocoons, as well as the silk, used to be bought principally by merchants who came from Gifu, in the province of Mino. Now, customers also arrive from Echizen, Oshiu, Echigo, Yonezawa in Dewa, and from other places. The best sort of silk is sold, as we are informed, at about 840 riyos a picul; the inferior sort at about 530 riyos a picul. A stout kind of netting is manufactured from silk, and it is also made up with other raw material, such as cotton.

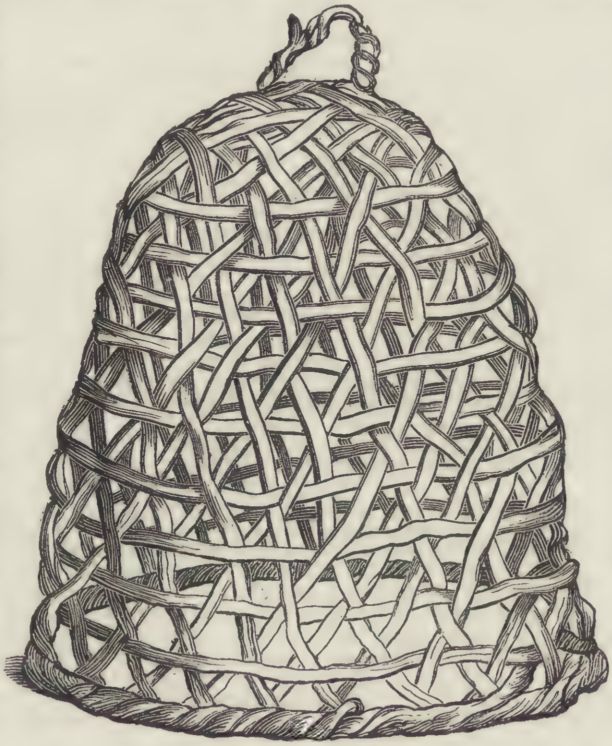


Fig. 8.—CAGE OF BAMBOO STRIPS ON WHICH THE EGGS OF THE BOMBYX YAMA-MAÏ ARE DEPOSITED.

"Close up to the western ranges of hills are a number of plantations of the 'Kunogi,' which is considered by the rearers of Furumaya and its neighbourhood to be the best food for the *Yama-Maï*. Its leaf is pronounced to be that of the *Quercus serrata*. The worms can be fed on other varieties of oak-leaves, but those of the 'Kunogi' alone are used for the purpose in this district. The plantation at Furumaya is less than a square mile in extent, and is thickly covered with plants of the species in question, some mere shoots of a year's growth, others varying from one or two to five or six feet, and others even taller. These plantations were said to extend at intervals for a distance of fifteen miles along the west side of the valley. The most approved method of propagating the 'Kunogi' was stated to be by sowing seed in a separate piece of ground, and then taking up the young plants and transferring them from these nurseries to the plantations. We were told that they are cut down close to the roots every three or five years, in order that fresh shoots might be given out. The soil is light and very sandy. The region is cold, and the leaves are often injured by the frost. The land belongs to peasants, who let it out in lots to different breeders, and there is a sort of rough surveillance, especially just at the period of spinning, but no particular watch seems to be kept, nor any thieving from man to be apprehended. The real thieves appear to be sparrows and other birds, and though some scarecrows are put up, and guns are said to be let off at times, no serious attempt is made to put a stop to such ravages. The leaves, too, are infested with other caterpillars, and we were told that red ants, though not prevalent in this particular locality, did damage. Black ants, too, were noxious when numerous, but nothing was done to prevent them from going up into trees, where we saw them sometimes swarming about the *Yama-Maï* in great numbers. In fact, in this, as in every other matter, the general principle of letting things take their course, and of leaving the issue to Providence, was plainly and painfully manifest.

"The larvæ were mostly in the fourth and fifth stages, and it was a curious and most interesting sight to watch them clinging to the branches and leaf-stems, and to observe how completely their colour corresponded with the leaf on which they most delight to feed. Their bodies were of a pure and almost transparent green, with a bright line running down the sides, ending in a brown patch, the two quicksilver-like spots on each side being plainly visible. Diminutive blue spots were also to be seen at intervals along the body. So much did every colour and streak resemble the plants to which they clung, that it was some time before our eyes became sufficiently practised to distinguish them at all without close examination. The annexed sketches (Fig. 7) will give an idea of the larvæ upon the trees.

"The eggs of the *Yama-Maï* are deposited by the female on the bars of cages made of plaited bamboo strips, of the bell-like form delineated in Fig. 8. This is probably towards the end of July, and the cages are hung up one under the other, in rows of ten, under the eaves of the roof, where ventilation can be secured without exposure to sun, rain, or smoke.

"In the tenth month (November—December) it is generally the custom to take the eggs off the cages with the fingers, and place them in hempen trays of oblong form, with wooden rims about three inches high. Care must be observed that the eggs are not crowded one upon another. The trays are placed upon the verandah. A cold atmosphere is essential at this stage. Sometimes the eggs are not detached from the cages, and the latter are placed in a shed outside the houses, where good ventilation can be secured. The walls of the shed are formed of a coarse matting composed of reeds, and the roofs should be constructed of such material that no rain can penetrate inside and injure the eggs.

"About the end of the second Japanese month (say the beginning of April) the eggs are collected in small hempen bags, which are placed in boxes pierced with holes, in order to admit of proper ventilation. These boxes are either suspended out-of-doors amongst the trees, where no sun can reach them, or kept in a cold cellar, where they are put into deep holes dug in the ground. This operation is only necessary when the hatching has to be retarded, because the buds of the 'Kunogi' have not come out. The eggs, in short, have to wait for the buds, which are expected about the eighty-eighth day after the Japanese new year (say at the end of April or in the first ten days of May), though they may be much later. As soon, however, as the buds have come out, all the eggs, whether from outside or

from the cellar, are brought into the house, and fixed with paste made of barley, or, still better, of buckwheat, on the middle of slips of paper five inches long and a quarter of an inch broad. About ten eggs are placed upon each paper, and all the slips are then taken to the plantation and tied to the branches of the 'Kunogi' in a single knot, which the nature of Japanese paper readily admits of, the two ends standing out at right angles to the branch. The paper thus surrounds a small section of the tree, the eggs lying on the external surface. The slips are placed in such a manner that the eggs may have a northern aspect, and not be exposed to the rays of the sun. One slip is sufficient for a small plant; two or three may be attached to a large one. In four or five days the hatching will commence, and it continues for five or six days more; the young caterpillars, on leaving the shells, immediately crawl from the papers upon the 'Kunogi,' and seek the leaves. We saw a number of these papers still remaining on the trees as the action of a charcoal brazier, are reeled. Those which rattle on being shaken are considered to be in good condition, and such of them as are to be reserved for seed are placed in trays, and moths emerge in about twenty-five days from the time of spinning. The remainder are of course subjected to heat, in order to kill the chrysalids, and are reserved for reeling.

"The moths emerge between four in the afternoon and night, and the great majority of the first moths are males. The proportion was stated to us to be 300 males to 10 females. The males are then secured in the bell-shaped cages already mentioned, and as the females emerge, they are distributed among the males. It would be best, we heard, to place but one couple in a cage: in practice, however, several couples were put into the same, otherwise there would not be sufficient cages. One of the men said he had as many as 500. The bottoms of the cages are then closed with paper. The coupling commences in the

Fig. 7.—SKETCHES SHOWING THE SIMILARITY OF CATERPILLAR OF BOMBYX YAMA-MAÏ TO LEAVES ON WHICH IT FEEDS.

they had been tied before the hatching, with the empty shells sticking to the surfaces, and we untied some and brought them away with us as specimens.

"The length of time between hatching and spinning, during the whole of which the larvæ remain in the open air, passing through four periods of rest, is reckoned at about sixty days, more or less, according to the temperature. We were told that the first rest commenced on the seventh day, and continued for two days; that the succeeding three periods of activity and torpor were severally longer than the first, and that the spinning commenced about ten or eleven days after the fourth rest.

"Three days after the commencement of spinning, said our informants, the hinder part of the cocoons is seen to be stained a white colour. This comes from the secretion of the *Yama-Maï*, which it emits after having finished spinning. The cocoons are then taken off the 'Kunogi,' together with the leaves to which they are attached, and a small portion of the branches. They are then brought into the house, and placed upon shelves. About ten days subsequently, the leaves are stripped off, and the cocoons, held by the lower and broader ends, are shaken. Those which do not rattle are considered to contain dead chrysalids, and after having been dried through evening, and lasts ten or twelve hours, after which the males are thrown away and die. It happens now and then that other males, coming from a distance, fly to the bars of the cages and couple with the females inside; these, however, are looked upon, not as legitimate husbands, but as interlopers, and their presence or absence does not enter into the calculations of the rearers of this district. The females then lay their eggs, as already stated, on the bars of the cages. This operation lasts four or five days, the average number of eggs to each female being estimated at from 150 to 200. The females then die. The best eggs are those laid on the first two or three days, and it is considered preferable that the males which emerge on one evening should couple with the females which emerge on the following evening. The same process which has already been described is then adopted with the new eggs.

"With regard to other diseases, they stated that after the fourth rest dark spots sometimes came out upon the worms, which subsequently die before spinning; that they are also subject to attacks of diarrhœa, which prove fatal; that another disease shows itself by a watery fluid exuding from the pores, the worms turning a brown colour and then dying. No particular names appear to be given to these maladies. Our

informants also said that if a considerable amount of rain falls whilst the egg papers are attached to the 'Kunogi' in the open air, the eggs are apt to be spoiled.

"We were shown a species of creeping plants called 'tonzuru,' with leaves resembling those of the convolvulus, and a dark stem, which sometimes cling to the 'Kunogi.' If the *Yama-Maï* eats of these leaves it is poisoned, and dies at once."

Sufficient evidence has now been given respecting this silkworm to show that there is a fair chance of success in suitable localities, and we are inclined to believe that the solution of two points will greatly help experimenters to the desired success. 1. It seems desirable that the culture of this worm should be tried on a large scale in a wood of some extent favourably situated; the worms might be fed in the open air, on the low-growing scrub, where the loftier trees could afford them shade without interfering with ventilation. A few streams running through the wood would be an advantage, and the aspect should be north rather than south. Lastly, not less than 10,000 eggs should be operated upon. 2. The *Quercus serrata* and other Japanese oaks differ very greatly in growth and appearance from our indigenous species. The Turkey oak (*Quercus cerris*) and the allied varieties most resemble the Japanese kinds, and certainly seem to be preferred by the worms. Large plantations of this oak I can remember at Burnham Beeches, near Slough, some twenty years ago: a locality, I should imagine, very favourable for an experiment. It might be worth while to keep this point in view. Another Japanese oak, which was sent to me in acorn, and on which the *Yama-Maï* is said to feed, has a very large leaf, much resembling that of the *Quercus ruber*.

It must be evident, from the information which has already been given on the culture of the silkworm, that it would be a very desirable acquisition to any country, and that could we, through its medium, turn the leaves of our oak coppices into silken fibre, it would be an enormous gain to this country. There are difficulties yet to be surmounted; but inasmuch as most Japanese plants and seeds flourish in Great Britain, I cannot but believe that with a little more information we shall be able to naturalise in the cooler and moister localities of Great Britain and Ireland this *Bombyx* and its valuable product, the strong raw silk that the moth produces.

FORTIFICATION.—XI.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DEFENCE OF ISOLATED BUILDINGS AND POSITIONS.

It occasionally happens that in times of insurrection, and also in the ordinary operations of war, small bodies of troops are forced to shut themselves up in isolated buildings, and to continue their defence for some time. The short time that would probably be available under such circumstances must generally preclude the possibility of collecting sufficient supplies to enable the garrison to stand a siege, even if the buildings happen to be of sufficient strength to resist a continued and serious attack. Hence it cannot often happen that any very prolonged resistance would be possible, although in the Indian mutiny there certainly were several instances of its having been done; the most memorable examples, perhaps, of the defence of a single building being that of a house at Arrah, held by a few men against the Dinapore mutineers, and the defence of the Residency at Lucknow, which, with its neighbouring buildings and enclosure walls, formed a large isolated post, and withstood a siege of some months.

There is no doubt that if a building has been well chosen, and its defensive capabilities made the most of, a very formidable resistance may be made against greatly superior numbers, when the assailants are not assisted by artillery fire. This latter condition, however, rarely happens in the fighting between regular troops, and hence the great difficulty of determining what should be done in each case, the total destruction of the building and its defenders being a mere question of time, provided the possession of the post is of sufficient importance to the enemy to induce him to concentrate the fire of a large number of guns upon it.

In any well-built house, not only are the walls bullet-proof, but there are usually ample materials within it with which to barricade the doors and windows, so that, provided every part of it is thoroughly seen and flanked by some other, it will be almost impossible for the enemy to get sufficiently close to blow an opening in the walls by exploding bags of powder or discs of gun-paper (dynamite) against them. Most buildings are constructed with projecting porches, outhouses, walls, or balconies, which may be readily converted into flanking defences. It does not, however, often happen that these means exist for such a complete defence in every direction that it would be impossible for a small party of men to place powder-bags against some of the walls without being seen. Wherever such a deficiency exists it must be supplied by temporary constructions, or such an accumulation of obstacles must be made round the weak point that any close approach would be impossible, at all events without so much preliminary work as to arouse the garrison and draw on the working party the fire from numerous loopholes. It may at first sight appear a theoretical and fanciful idea to provide flank defence for such short lines as the gable ends of houses, etc.; but it must be remembered that if infantry, unassisted by artillery, are attacking other infantry who are in possession of a loopholed and fortified building, the weapons of the assailants are almost powerless against the defenders, whereas every shot fired deliberately and in almost perfect safety from behind a loophole should take effect outside. The advantage, therefore, lies entirely with the defence, and the only chance remaining for the attack will lie in being able, by a surprise of some sort, to send a few men forward to place bags of powder against the walls, the explosion of which will form an opening sufficiently large to enable the assaulting troops to rush in.

This operation of placing the powder is very simple, and to perform it only three or four men and a very short time are necessary; but being so few in number, and each man having certain definite work to do, it is essential that they should be able to perform their task without casualties, an event that would seem impossible if even one or two men are placed in a secure position for flanking the wall with revolvers or breech-loading rifles.

The two most ordinary modes of obtaining this flank defence are by "tambours" and "machicoulis galleries." The former are a species of kaponier, with or without a roof, formed of stockade work, and projecting sufficiently from the wall to flank it by the fire from several loopholes. As in all stockaded buildings, the labour necessary for their construction is considerable, and the liability to destruction by artillery fire is very great. They are, therefore, often impracticable, and cannot be adopted; although in cases where there are ample means and time available they may be of great use. The Prussians employed them frequently in their lines of investment for flanking long walls which were too extensive to be powerfully held without some such assistance, and which if unflanked would have afforded cover to the enemy without materially checking his advance. The long wall forming the enclosure of the "Haras," near Garches, in the lines round Paris, was defended in this way.

The defence by machicolated galleries is a very old one, and may be seen in most old castles or fortified buildings of the Middle Ages, where approach to the foot of the wall is prevented by the fire from loopholes in the floor and sides of small projecting balconies supported on corbels near the top of the building. The modern machicoulis is a wooden balcony with bullet-proof front and sides, supported on beams which project through holes in the outer walls sufficiently far to allow of a vertical defence by means of pistols and short rifles. It is troublesome to construct, and so easily destroyed by artillery, that if the close approach of the enemy can be prevented by any other arrangement, it will often not be worth while to employ it as a means of defence. A bullet-proof screen or shutter placed in an inclined position, like a sun-shade, at a window or other opening, may with less labour be arranged so as to hide the defenders from view, and at the same time admit of a vertical defence for the wall.

In the choice of a building for defensive purposes, next to the important question of flank defence, its liability to be set on fire, and the means by which this difficulty may be met, should be carefully considered. There must be an ample water supply, thatched roofs and inflammable out-buildings must be removed, and all hay-ricks or stacks of firewood near to it must be burnt or destroyed, as a conflagration on the windward side

of a house at the moment of attack would vastly increase the difficulties of the defenders, even if it did not result in setting fire to the building itself. There should be a clear space for some distance round the house, affording no cover for the enemy's marksmen, and its position should be such that, while it commands the roads by which the enemy will probably advance, it is not itself commanded by the roofs and windows of other more lofty buildings within range. As regards the work to be done inside the building: in the first instance carefully barricade and loophole the basement and ground floor, constructing and accumulating as many obstacles as possible round the outside. Care, however, must be taken that in the endeavour to obtain a powerful fire the lower walls are not so weakened by breaking numerous loopholes through them that the general stability of the building is affected; for it must be remembered that under the fire of artillery portions of the walls will be carried away, and that the weight of the roof, floors, etc., eventually may have to be borne by only a portion of their original supports.

It is generally considered that the garrison of the lower storey should be more numerous than that of the upper; and doubtless if without danger to the building sufficient numbers of loopholes can be made to employ the available number of men, there is an advantage in so doing, as the fire at that level will probably be more destructive than the plunging fire from above. As a rough guide to the number of men wanted, exclusive of the reserve, it is generally assumed that one man for every six feet of wall-space upstairs will suffice, and that the men are somewhat closer packed below; a considerable reserve being always kept in hand to replace casualties and perform various duties, such as cooking, etc. No rule of this kind can, however, be of much real value, as so much must depend on the shape and size of the building and the circumstances and object of the defence.

Loopholes at the angles of a building have a greater range, and enable fire to be directed on the sectors of undefended space in front of the angles, but they are more difficult to form than the ordinary ones. The great increase of power that has resulted from the use of breech-loaders renders it less necessary than formerly to crowd the men closely together, and every effort should be made to ensure their being able to use their rifles with freedom and effect. In the flanking defences, where the men have only to fire in one fixed direction, and where it is very important to get as much fire as possible from a given length of flank, there seems no reason why they should not be placed as close together as when standing in the ranks, provided long horizontal loopholes can be made for them to fire through.

In walls three feet or less in thickness, the neck or narrow part of the loopholes should be on the outside, and not less than three inches wide. The bottom of the loophole or sill should be about 4 feet 3 inches from the floor or banquette, and when considerable depression is required this height must be reduced. Pickaxes, crowbars, and hammers are required for making loopholes; and in ordinary brick walls, from nine inches to two feet thick, a couple of men should make a loophole in from ten to twenty-five minutes. The increased penetration of modern rifles renders the task of rapidly providing bullet-proof protection for the doors and windows of a defensible building more and more difficult. Boxes filled with earth, and sandbags or pillow-cases filled with earth and carefully built up, will answer the purpose, if they can be obtained in sufficient quantities. Doors and window-shutters can be rendered partially bullet-proof by nailing several extra thicknesses of planking diagonally across them until the required height of cover is obtained. When it is remembered, however, that our new infantry weapon, the Martini-Henry rifle, is capable of penetrating three thicknesses of three-inch fir planking at fifty yards, it would appear almost hopeless to try to obtain security by this means. Logs of wood, rolls of carpet, chests of drawers filled with earth, etc., can all be made use of with more or less success, and if perfect protection cannot be obtained, cover from view will often be of much use. It is important that the enemy should not be able to see whether the loopholes are manned or not, and therefore by day there should not be too much light in the rooms, and at night the less number of lights in the building the better.

Much has been said by various writers on the advisability of preparing for a defence of a building from room to room, and for a retreat from the lower floor by means of ladders to the upper rooms, from the floors of which a fire can be maintained on the enemy below, who are unable to follow, owing to the removal of the ladders and ordinary staircases. Such obstinate defences as this have undoubtedly often occurred, and therefore it would be presumptuous to say that under certain circumstances it may not be advisable to adopt similar measures again. It does, however, seem clear that if the assailants, in spite of the fire from the building, can succeed in forcing an entrance, and if, in spite of the equality of the fighting when they can only enter two or three abreast, they are able to drive the defenders to take refuge upstairs, it will not be long before they are able either to explode bags of powder in the lower rooms or to set fire to the house, which would probably at once put an end to the defence. It would, therefore, appear more advantageous to devote every effort to render the approach to the outside of the house difficult, rather than to elaborate a system of internal defence, which may possibly never be required. The foregoing remarks have been made chiefly with reference to a single building, but they will also apply generally to any group of buildings which has to be defended by infantry as an isolated post. Of course, where the buildings are not already connected by walls, out-houses, etc., the enclosure must at once be completed by means of stockades, abattis, etc., and where this has been done the same general arrangements as have been described would be adopted.

Isolated groups of buildings or villages may have to be defended under such very different circumstances that it will be impossible to do more than notice a few of the most ordinary cases. They may be occupied to assist the rear-guard of an army in covering its retreat, or the leading detachments of an attacking force may seize them, simply in order to enable them to hold their ground until the mass of their troops can be brought up. They may also have to be defended because they form important advanced posts in front of a large defensive position occupied during a general action. The defensive object in each of these cases being somewhat different, the nature of the practical work to be done in each case will also to a certain extent vary.

In the two former cases the object is obviously to gain time, and as the direction of the attack they are likely to receive is known, they need not necessarily be treated as closed works, but rather with reference to defence in certain directions only. In other respects, however, the conditions are dissimilar, for in the case of a rear-guard it may occasionally be necessary for the buildings to be obstinately defended to the last, even if by so doing the garrison is annihilated or taken prisoners, though of course the retreat of the defenders should as a rule be carefully provided for. This is essentially one of those cases where preparations for a successive defence from house to house, and from every advantageous point along the line of retreat, can and should be arranged. In retreating, the main body of the force will have passed through the village some time before the rear-guard arrives; consequently the officers in command have the opportunity of examining its capabilities for defence and designing their scheme, the necessary working parties and tools for carrying out which they probably have the means of supplying. This process should be repeated at convenient intervals along the line of retreat, and the rear-guard itself will be guided by orders received from the main body how long to continue its resistance at each point and when to retire.

The measures to be taken by an advanced guard occupying a village temporarily will differ from the foregoing inasmuch that the commander has probably no previous knowledge of the place, has probably a very short time in which to arrange his plans, and no resources as regards tools or materials besides those carried by his own men, as the inhabitants will most likely have fled. Here it is evident that every effort will in the first instance be made to strengthen the front and flanks of the village without barricading the streets, etc., in any very solid way, lest by so doing the subsequent advance of the main body should be delayed. With a rear-guard, on the contrary, as the roads and streets can only be of use to the enemy, any obstacles whatever that will delay his advance must be employed. The regularly-organised advanced guard of a large army would probably have a sufficient force of engineer officers, and men to do any requisite work but during a long general action the

success at some one point may cause the enemy temporarily to retire from a village, in which case, if there are no engineers at hand, it should be at once seized and fortified by the nearest battalions of the attack, when great judgment will be required to turn the small amount of work possible to the greatest account. Any success of this kind should be promptly supported by numerous bodies of engineers from the reserve, carrying with them the tools and implements most likely to be of use; and if, owing to the fire, they are unable to work at strengthening the front line, they should be actively employed in retrenching the position and loopholing houses, which will enable the troops to remain in the village even after the outskirts have been re-captured by the enemy.

When the buildings to be defended are in front of a line of battle, there probably have been some few hours available for preparation, and an ample garrison can be left for their defence. The difficulty, however, is to devise any arrangement that will enable them to hold out for several hours under a concentrated artillery fire, and surrounded by the enemy's troops. Being nearest to his position, they will have to withstand the first brunt of the attack, and are sure, for a time at least, to be cut off by the wave of attacking troops as it rushes forward to assault the main position beyond. In these cases it is evident that they must be capable of resistance in all directions, and also that a means of communication on the side next the position should invariably be made, by which, when a favourable opportunity occurs, reinforcements of men and ammunition may be sent to their assistance. The celebrated farm buildings of Hougoumont and La Haye Sainte, that played so conspicuous a part in the battle of Waterloo, belong to this catagory; and in the late war in France there were numerous examples of buildings defended under similar circumstances—for instance, the farm-house of St. Hubert, about 1,000 yards in front of the French left centre at Gravelotte, and the farm of La Bergerie, near Mont Valerien, which was so stoutly defended by a company of Prussian infantry against the last great sortie from Paris, 19th of January, 1871.

The defence of the village of Le Bourget, and numbers of others round Paris and Metz, will be found most instructive examples for any one really wishing to study the subject. Fairly reliable facts as to time, men employed, etc. etc., and a description of what was done, may in all such cases be gathered from the official French and German accounts.

In some cases the buildings in a village or town are so grouped as to be rapidly capable of conversion into a strong fortified post; while in others these conditions are most unfavourable—as, for instance, where the houses form one long street, enfiladed from the enemy's position, and liable to attack on either flank. Under these latter circumstances, it is clear that the enemy's artillery will in a short time render the defence of the end houses of the street an impossibility, and that any attempt to hold them would be futile. It would seem best in such a case to hold, in the first instance, an advanced line of trenches traced so as to avoid enfilade as much as possible, and when obliged to leave these to retire to houses, which being further up the street, are not so likely to be ruined as the end ones. These houses must have been previously determined on, and loopholed, the barricades in the street being so placed as to be commanded by them. The houses so chosen should if possible be isolated from the others on the side next the enemy, or if this is not possible, the floors and partition-walls of the houses next to them should have been cut away, to prevent the enemy working from house to house after he has once gained the end of the street. If the barricades are manned, the assailants will avoid a direct advance up the streets, and will endeavour to command and turn them by fire from the roof and windows of the houses they first get possession of. If the defence has been carefully prepared, these houses should have been previously mined, so as to be blown up as soon as the enemy's troops appear to have occupied them in force. To avoid this, no buildings should if possible be occupied by large crowds of troops until they have been examined by the engineers, with a view of detecting the mines, and disconnecting the wires or powder hose with which the charges would be fired. As regards barricades, they should be made at places where they are flanked, and where, if possible, they are screened from direct artillery fire, and there should always be a means of retiring round them, through the houses right and left.

In the attack of a fortified village, the assailants will endeavour by a series of false attacks to deceive the defenders as to the point on which the real attack is to be made. The troops, however, making the feigned attack should be sufficiently numerous and well organised, that if they find a weak or unguarded point they can really assault the place. The artillery will be used as usual to enfilade the longest lines, dismount the guns, and destroy the flank defences and obstacles. The fire of the defenders will be kept down by the artillery and by the leading division of the attack, who advance in skirmishing order, closely followed by a large working party of engineers, to destroy the obstacles, and prepare an entrance for the stormers.

In order not to give the defenders time to assemble it is very necessary that the attacking troops should advance as rapidly as possible, but before entering the village it is of still greater importance that until the working parties have cleared the way there should be no confusion or mixture of the troops having separate duties to perform.

After once an entrance has been effected, all previous arrangements must be more or less upset; and the success of the attack will depend on the vigour with which it is pushed forward, and the numbers with which it is supported. While the storming party is forcing its way onward, a working party should be employed in fortifying any houses or buildings favourably situated for covering the retreat in case of a reverse. Subject, of course, to variations depending on the circumstances of each case, the following is the general organisation of an attacking column:—(1) Skirmishers; (2) engineer working party; (3) escalading party, carrying ladders, ropes, grapnels, etc.; (4) storming party of infantry, followed by supports and reserves. The intervals to be observed between these, as well as their numbers, will entirely depend on circumstances. The hour for these attacks is usually just before dawn, as this allows of the assembly of troops and first advance possibly being made unseen, and of the subsequent operations being facilitated by the increasing daylight.

TECHNICAL DRAWING.—LXVIII.

DRAWING FOR BRICKLAYERS.

THE methods of breaking joint in short portions of walls built according to the common English bond having been thus illustrated, it now remains to treat of the system to be adopted in effecting the same object at the corners of buildings where two external walls meet at right angles.

In this case it is proper, commencing as usual from the corner header, at the external angles to introduce a set of closers, covering an extent equal to the whole thickness of the particular wall of the two (that is, if the two walls be of unequal thickness, which may often occur in practice) to which that header belongs; while closers need not, however, be disposed in a continued straight line, but checkerwise, so as to approach towards the re-entering angle, but without actually reaching it, and thus none of them will be seen in the inside of the building. They must all be laid parallel to each other.

Figs. 559 and 560 represent this arrangement, showing two successive courses of the corner of a building formed by the meeting of two walls each supposed to be three bricks thick.

In this arrangement it will be observed that of the two walls which meet each other at the angle, one shows a stretching course, whilst the other shows a heading course on the same level, and *vice versâ;* and these two arrangements meet each other at those parts of the brickwork where the three closers, which are equal in all to the length of three bricks (the thickness of the wall), extend entirely across the wall.

In building English bond a variety may be introduced by using so many three-quarter bats instead of whole bricks as corner headers at the extremities of every heading course as will make up the thickness of the adjoining wall; and in this case no closers are required.

Figs. 561 and 562 represent the plan of the corner of a building in which the walls are three bricks thick, and where this arrangement has been followed. In each heading course six three-quarter bats are used near the angle, which extend over a space equal to three bricks—that is, the thickness of the wall. In this case it is evident that all the joints will be perfectly broken without the aid of closers. These three-quarter bats are visible in Fig. 562, in which it will be seen that the

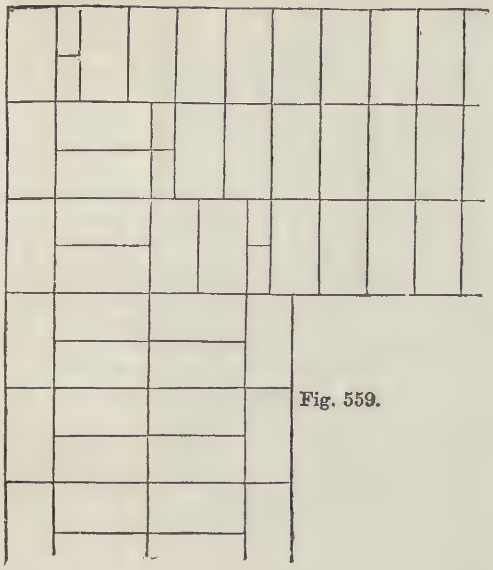


Fig. 559.

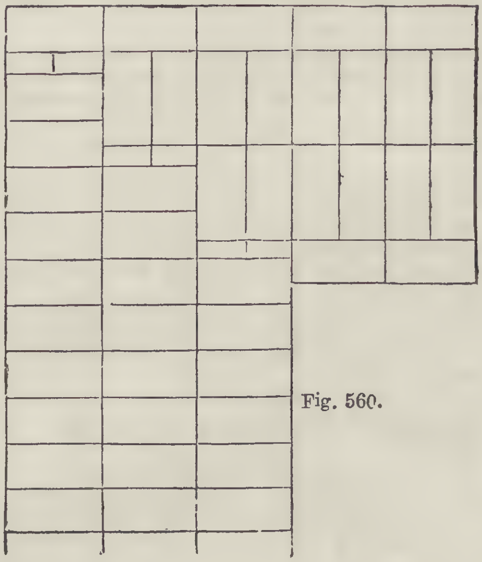


Fig. 560.

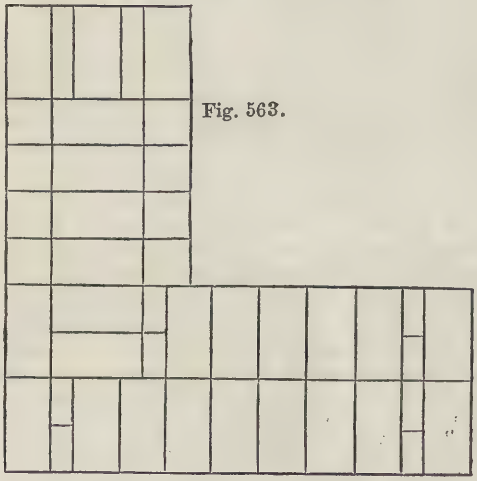


Fig. 563.

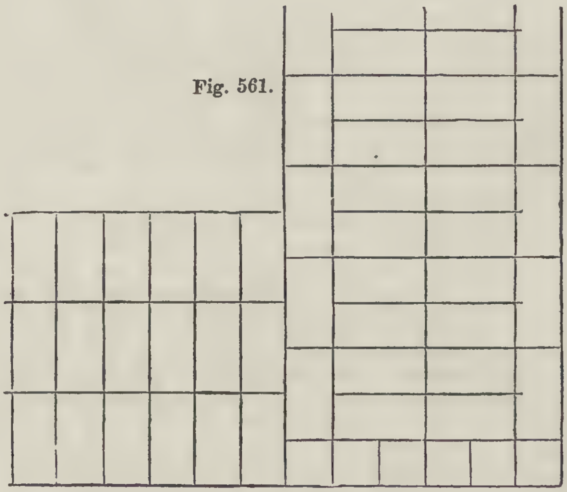


Fig. 561.

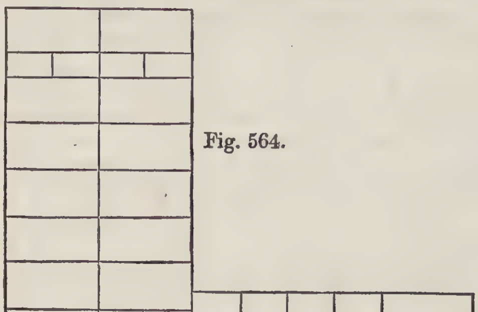


Fig. 564.

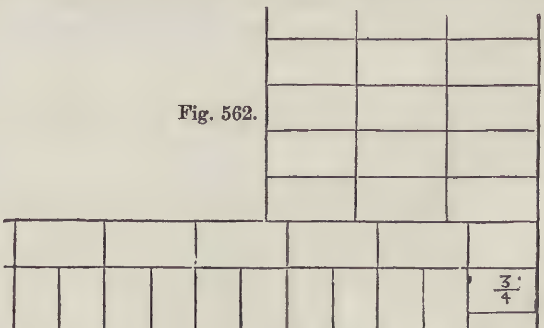


Fig. 562.

corner header of one wall shows as a short stretcher in the stretching course on the other side of the angle.

HEADING BOND.

A brick wall may be built all heading bond—that is, without using any stretchers at all, excepting in alternate courses at the corners of the building, as "quoins," as they are technically called, and at the various other angles or breaks occasioned by projections and recesses, or by the openings for doors and windows.

Figs. 563 and 564 represent the plans of two successive courses thus executed. One corner of the building is shown with the walls extending on each side as far as two openings, which may be supposed to be doors or windows.

Although from its neat appearance this style has been preferred by some architects, it is not generally considered so good as the common English bond, for as compared with that it merely consists in breaking every external stretcher into a couple of bats, as shown in Fig. 564, which certainly cannot be an advantage.

SEATS OF INDUSTRY.—XXVII.

LIVERPOOL.

BY WILLIAM WATT WEBSTER.

ALTHOUGH the manufactures of Liverpool are comparatively trivial, there is no town in the world that illustrates so clearly, and upon so extensive a scale, the indirect influence of manufacturing enterprise upon national prosperity. To its intimate connection with Manchester, Oldham, Bury, Bolton, Ashton, and other great manufacturing centres in the north of England, Liverpool owes, in a great measure, the proud position it occupies as the second town in the kingdom as regards population, and the first port in the British Empire, and consequently in the world, as regards the extent of its foreign trade. It is an integral and highly important part of the manufacturing system of England, and the story of its rise and progress, especially in later times, forms an interesting and instructive chapter in the history of British industry.

The etymology of the name Liverpool has given rise to much conjecture; but no satisfactory explanation of it has been given. In the earliest authentic records of the town that have been preserved, it is called Lyr-pul, and it has been suggested that the name is derived from the Gaelic word Lyr, "the sea," and that Lyr-pool means the "harbour of the Mersey." On the assumption that Leverpoole is the original orthography, the name has been associated with the family of Lever, which in ancient times flourished in the county, and also with the cormorant in the corporation seal, which is known in heraldry as a laver or liver. Previous to the Conquest, Liverpool was but a small and obscure fishing village; it is not mentioned in the Domesday Book. Ten years after William of Normandy landed in England, it is believed that a castle was built on a promontory between forty and fifty feet above the river, by Roger of Picton, on whom the Conqueror bestowed the whole district between the Ribble and the Mersey, and that the houses built round the base of this promontory formed the nucleus of Liverpool. There is a tradition that Henry I. conferred a charter of corporation on the town in 1129; but the charter of Henry II., dated 1173, is the first authentic record in its history. This document declares that "the estuary of the Mersey shall be for ever a port endowed with all the liberties belonging to a port of the sea, and that the men of Lyr-pol near to Toxteth may come and go from each side of the sea with their ships and merchandise, free and without obstruction," the sea here referred to being, of course, the Irish Sea. Henry II. also erected a number of what were called burgage-houses, whose tenants were the primitive freemen of Liverpool, and the Crown continued to draw the rental of these houses up to the time of Elizabeth. In 1207 King John granted a new charter, and in 1229 Henry III. made Liverpool a free borough with a merchant's guild and house, and conferred on its burgesses like liberties and privileges to those enjoyed by their brethren in London, Bristol, and other towns, no stranger being allowed to trade or settle there without the sanction of the municipal authorities. For two centuries this smallest of the chartered towns of England was so poor that it sent no representative to Parliament, and for five centuries it can hardly be said to have had a history. During the latter long period, the wardership of the castle was retained by members of the Molyneux family; and about the year 1360, a tower that had been erected in the previous century, as an outguard to ensure the safety of the castle, came into possession of the Stanley family, and this building was afterwards an occasional residence of the Earls of Derby. In the reign of Henry VI. the Stanleys and the Molyneux had a violent feud, which required the intervention of the Government; and about this period the knightly family of More, of Bank Hall, had a mansion in Liverpool and large possessions in the vicinity. In 1524 Leland describes the town in his "Itinerary" in the following terms:—"Lyrpole, *alias* Lyverpoole, a pavid towne, hath but a Chapel, Walton a iiii miles of, not far from the Se is paroche chirch, the King has a castelet there, and the earls of Darbe hath a stone house there. Irish marchaunts come much thither as to a good haven. At Lyrpole is small custume payed that causith marchauntes to resorte. Good marchandis at Lyrpole, and moch Yris yarn that Manchester men do buy there." Forty-one years later Stow states in his "Survey" that Liverpool consisted of seven streets, containing 138 houses, and that its population numbered only 690. There were then in the harbour twelve ships, with an aggregate burden of 223 tons, and a total crew of seventy-five men. In a petition to Queen Elizabeth, dated 1571, reference is made to the place as "Her Majesty's poor decayed town of Liverpoole;" but Camden, writing in 1586, gives a more cheering description of it, noting, among other things, that it is "the most convenient and most frequented passage to Ireland," and remarking that the town was "more celebrated for her beauty and populousness than for her antiquity." It would appear that the merchants of Liverpool had trading connection with the continent of Europe at this date, for it was Humphry Brooke, one of their number, who gave Queen Elizabeth's Ministers the first intimation they received of the sailing of the Spanish Armada; but its chief trade was at that time, and for a long period afterwards, with Ireland. Chester, however, continued to be the principal seat of commerce with Ireland till about the middle of the seventeenth century. The transfer of this trade from Chester to Liverpool began by merchants of the former town using the latter as their port, the Dee having gradually become unnavigable for the larger class of ships, and for many years Liverpool was considered a sort of sub-port of Chester. In 1602, the inhabitants of the latter town asserted that "the town of Liverpool was but a creek of the port of Chester," and for many years they claimed a sort of lordship over Liverpool. In 1626 a new charter was granted to Liverpool by Charles I., making it a city, James Strange, Lord Stanley being its first mayor; but up till 1647 the port was subject to Chester officers. After the Irish rebellion of 1641, a number of Irish Protestants settled in Liverpool. During the civil war the town acquired great political importance. In 1644 it was defended by Colonel More against the army of Prince Rupert for three weeks, but was taken by storm: the royalist cause, however, being shortly afterwards utterly ruined by the defeat at Marston Moor, Liverpool again came into possession of the Parliament. Cromwell favoured the place as the most convenient port of embarkation for Ireland, and during the great plague and fire of London in 1665 and 1666, many merchants from the metropolis took up their residence in Liverpool. In Blome's "Britannia," dated 1673, it is stated that amongst the inhabitants of Liverpool are "divers eminent merchants and tradesmen, whose trade and traffic, especially into the West Indies, makes it famous," and "the sugar bakers and great manufacturers of cotton in the adjacent parts" are mentioned. During the reign of Charles II. Liverpool made great progress, owing to the opening up of America to British enterprise, and its merchants early took an active part in the slave trade, sending out ships to Africa for negroes, conveying them to America, and bringing back sugar, tobacco, and other goods, in exchange for their live cargoes. It was from Liverpool that William III. set sail for Ireland in 1690, three days before the battle of the Boyne. Nine years later, when it was erected into a separate parish, Liverpool had a population of about 5,000.

Liverpool advanced rapidly during the eighteenth century, chiefly by means of the trade its merchants carried on in slaves and tobacco. The first slave ship fitted out on the Mersey was dispatched in 1708; but by the year 1752, 101 Liverpool merchants were engaged in this infamous though lucrative traffic. Between the years 1700 and 1709 inclusive, the average annual

importation of tobacco into Britain amounted to 12,880 tons, and Liverpool had a larger share of this trade than any other port in the kingdom, half the shipping and more than half the wealth of the town being embarked in it. To afford facilities for this trade, a wet dock was constructed in 1709, which was not only the first in Liverpool, but the first in the kingdom. By the year 1760 there were seventy-four vessels belonging to Liverpool, with an aggregate burden of 8,178 tons, engaged in the slave trade, and it continued to increase during the forty-seven years that elapsed before England ceased, in 1807, to participate in this iniquity. During the ten years from 1795 to 1804, when the slave trade reached its culminating point, it is calculated that the merchants of Liverpool shipped no fewer than 323,770 slaves from Africa to America and the West Indies. That this traffic was highly profitable to them, may be inferred from the fact that at the time it was being carried on, the greater part of the West Indies belonged to Liverpool merchants. The outbreak of the French war in 1756 put a stop for a short period to the slave trade, and the slavers of Liverpool were turned into privateers. At first they gained some slight success, but before the close of the war Liverpool suffered severely by way of retaliation, it having been blockaded by French privateers for seven weeks in 1758. In the course of the eighteenth century, the natural advantages of Liverpool for the prosecution of commerce were greatly enhanced by the construction of an immense system of canals. The first effort to improve the natural facilities for inland trade was the building of the Irwell and Mersey navigation (for which an act was obtained in 1720), by means of which raw cotton and cotton goods were conveyed to and from Manchester; and shortly after the completion of this work, the Weaver navigation was undertaken, which afforded an easy means of bringing the salt of Nantwich and other places in Cheshire to Liverpool, which speedily became an important article of export, and employed a large amount of shipping. These works were followed by the Sankey Brook navigation, completed in 1768; the Bridgewater canal, opened in 1773; the Trent and Mersey, or Grand Trunk canals; and the Leeds and Liverpool canal, which were finished in rapid succession; so that by the year 1816, Liverpool possessed a complete system of water communication, direct or indirect, not only with the great manufacturing towns of Lancashire, Cheshire, and Yorkshire, but also with the south coast, and, in fact, with nearly every part of England. These canals have realised large profits to their shareholders, and they still bring in considerable revenues, notwithstanding the competition of the railways. It is worth mentioning that between the years 1777 and 1782, there were launched on the Mersey some fifteen war-vessels, of considerable tonnage, and carrying from sixteen to fifty guns, constructed to the order of the Government. As a matter of course, the population of the town kept pace with the growth of its trade. Between 1710 and 1760, the number of its inhabitants increased from 8,160 to 25,780, and the shipping belonging to the port increased from 84 vessels in the former of these years to 1,245 in the latter. By 1781 Liverpool had a population of 35,000, and possessed 2,300 ships; and by 1791 its population had augmented to 50,000, and its shipping to 4,200 vessels. In 1801 the population was 77,700, and the commercial fleet numbered 5,100 vessels.

But the most important factor in the prosperity of Liverpool has yet to be noticed, for it has been still more indebted to cotton than to slaves and tobacco put together. The beginnings of the cotton trade of Liverpool were exceedingly small. In a local newspaper, dated 3rd of November, 1758, the following advertisement appeared:—"To be sold by auction at Forbes and Campbell's sale-room, near the Exchange, this day, at one o'clock, twenty-five bags of Jamaica cotton in five lots;" and from that time cotton was regularly brought to Liverpool from the West Indies, although for a long time in exceedingly small quantities. In 1770 the imports into Liverpool included 6,030 bales of cotton from "the West Indies and from foreign countries, with the addition of three bales from New York, three bags from Georgia, four from Virginia and Maryland, and three barrels from North Carolina." Twenty-one years later only 64 bales of cotton came to Liverpool from America, but the total quantity imported from Portugal and the West Indies in 1791 amounted to 68,404 bales. In 1794, however, the supply from America had risen to 4,668 bales, and from that date American cotton came into the port in steadily increasing quantities till it largely exceeded the imports from the East, and became the staple article of the commerce of Liverpool.

It was not till Hargreaves, Arkwright, and the other inventors and improvers of cotton manufacturing machinery had created and developed the cotton manufactures of the north of England, that the cotton trade of Liverpool attained gigantic dimensions. In the year 1824, the quantity of cotton imported into Liverpool was 578,323 bales, and of this total 413,724 bales came from the United States of America. The total imports of cotton into England in 1830, from all quarters, amounted to 793,695 bales, and of this quantity no less than 703,200 bales came to Liverpool. Ten years later, 1,164,269 bales of cotton were brought to Liverpool, and in 1851 the quantity had increased to 1,748,946. It may be stated here that the quantity of foreign and colonial produce imported into Liverpool in 1858 was 1,384,353 tons, against 1,374,937 tons into London, and that the foreign exports from the former port amounted in the same year to nearly £35,000,000, or considerably more than one-half of the total value of the exports of the three kingdoms for that year, and more than twice that of London. The number of vessels that entered the port of Liverpool in 1851 was 21,071, representing an aggregate of 3,737,636 tons burden, and the dock dues amounted to £269,020, and the customs receipts to £3,510,033.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIX.—RICHARD REYNOLDS.

BY JAMES GRANT.

This celebrated iron-smelter, and ultimately the inventor of the *iron rail* which is now used on all railway lines, was born at Bristol in the year 1735. Though educated in the peaceful persuasion of the Society of Friends, to which his parents belonged, when but a lad he felt a strong desire to become a soldier, and would have enlisted but for the dismay such a step must have occasioned his friends. Ere long this fancy or enthusiasm died out, and assuming "the drab," he settled down into a quiet and industrious Quaker.

After serving an apprenticeship to the iron trade in Bristol, he went to Coalbrookdale on business; while there he became acquainted with the Darby family, who had long been iron and brass founders in that district, so rich in mineral treasures. The Darbys were also "Friends," and received young Reynolds hospitably, and eventually he married Hannah, daughter of Abraham Darby, known as "the second," three of that name—father, son, and grandson—having been smelters and malt-mill makers in succession at Coalbrookdale since the first year of the last century.

Richard, through this connection, undertook the management of the iron and coal works at Ketley and Horshay. At the latter place he resided six years, and on the death of his father-in-law, in 1763, he removed to Coalbrookdale, and took charge of the more extensive iron-works there. By the wealth and enterprising spirit of the Darbys, these had become greatly enlarged, and found remunerative employment for a rapidly-increasing population. The firm did not confine their operations to the Dale, says Mr. Smiles, but extended their works far beyond its boundaries, and built foundries in London, Bristol, and Liverpool, with agencies at Newcastle and Truro for the disposal of the steam-engines and other iron machinery then in use for clearing deep mines of water, and many of the pumping-engines made on Newcomen's design were constructed at the works of the Darbys.

"Civilisation is economy of power," according to Baron Liebig, "and English power is *coal!*"

The increasing demand for iron gave an impetus to coal-mining; the works increased in magnitude and number, till the whole of that part of the glen through which the Severn flows, between two hills, presented a *tout ensemble* which, with the forges, engines, furnaces, and machinery of iron, constitute a spectacle of the most interesting and bustling description; and when the steam-engine had been perfected by James Watt, and enabled powerful blowing apparatus to be wrought by its agency, the production of pit-coal being rendered cheap and expeditious, inventions stimulated each other, and trade at Coalbrookdale enormously increased.

The rich coal and iron district there includes the Dale, and

extends east to Lillieshall and Bridgnorth, north-west to Wellington, and thence by the wooded Wrekin, south-west to the road from Much Wenlock to Bridgnorth; on the west the boundary is broken by the Severn; but the area thus described consists of a platform raised 400 feet above the river at Madeley, and 500 feet above the sea. At all these points the coal-measures are fully developed, and next in importance to the beds of these are the layers of argillaceous carbonate of iron.

Up to the time when Richard Reynolds took charge of the works at Coalbrookdale, the conversion of crude or cast iron into malleable or bar iron had been effected entirely by means of charcoal. The process was carried on in a finery almost exactly like a smith's forge, "the iron being exposed to the blast of the bellows and in constant contact with the fuel. In the first process of fusing the ironstone, coal had been used for some time with increasing success; but the question arose, whether coal might not be used with effect in the second or refining stage. Two of the foremen, named Cranege, suggested to Mr. Reynolds that this might be performed in what is called a reverberatory furnace, in which the iron should *not* mix with the coal, but be heated solely by the flame."

Though doubting the success of the experiment, Reynolds encouraged the Craneges to attempt it in April, 1766, and the result of their invention surpassed the expectation of the three. The iron put into the furnace was old bushes, which are always made of the hardest metal, and the iron drawn forth was, according to Reynolds's own statement, "the toughest I ever saw. A bar, 1¼ inch square, when broke, appears to have very little cold short in it. I look upon it as one of the most important discoveries ever made, and take the liberty of recommending thee (Thomas Golding, of Bristol), and earnestly requesting thou wouldst take out a patent for it immediately."

His advice was followed, and a patent to the Brothers Cranege, as inventors of the process, was secured for them on the 17th of June, 1766; but other inventions superseded it, and thus it eventually was of no benefit to them.

Among the important improvements introduced by Reynolds at the Coalbrookdale Works was the invention and adoption by him for the first time of *iron rails*, in lieu of wooden tramways along those roads by which the metal and coal were conveyed to the furnaces and to the landing-places on the Severn. The first idea of constructing railways is supposed to have been entertained between 1620 and 1650, when they were roughly constructed of wood, and one of this kind existed at Preston Pans, in Scotland, for when the Highlanders routed the King's troops there, in 1745, the cannon of Sir John Cope were captured *on the railway*, or tram-road. Reynolds observed that the wooden rails soon decayed, were liable to be broken, thus interrupting business and incurring great expense for repairs; and to obviate these inconveniences, in 1767, he took up all the wooden rails and replaced them by plates of iron, thus fairly inaugurating the era of the iron railroad, and his example was followed on all the old tramways throughout the three kingdoms.

It was at his works that the *first* bridge of iron the world had ever seen was constructed in 1779, after long care and forethought, as an attempt had been made some twenty years before to span the Rhone at Lyons, and proved a signal failure.

The erection of the bridge was perhaps due to the energy and enterprise of his wife's kinsman, young Abraham Darby, who having become proprietor of the Manor of Madeley, and finding that the owner of Broseley, on the opposite side of the Severn, was equally anxious to bridge the stream where it divided their possessions, and where its banks were steep, and the old ferry dangerous, set about procuring plans for the erection without delay. Empowered by Parliament, a company was formed; shares were taken by the adjacent owners, the Rev. Mr. Harris, Mr. Jennings, and Mr. John Wilkinson—the latter a man of great enterprise, and builder of the *first* iron ship. Abraham Darby was the principal subscriber; and Mr. Pritchard, of Shrewsbury, prepared a plan, which, according to Mr. Smiles, is still preserved. It proposed to introduce cast iron in the arch of the bridge, which was to be in span 120 feet, but only as a sort of key, occupying but a few feet at the crown of the arch; this very sparing use of cast-iron indicating the timidity of the architect in working with new material. Thus, had his plan been adopted, "the problem of the iron bridge would still have remained unsolved."

It was set aside, and another arch *entirely* of cast iron was prepared at the works under the superintendence of Mr. Darby and Thomas Gregory, foreman of the pattern-makers, and arrangements were made for carrying it into effect. The abutments were built in 1778, and the following year saw the bridge —with an arch 40 feet high, and 100 feet in span—opened for traffic. The model of this structure is still preserved by the Society of Arts. "If we consider that the manipulation of cast iron was then completely in its infancy," says Mr. Stephenson, in the *Encyclopædia Britannica*, "a bridge of such dimensions was doubtless a bold as well as an original undertaking, and the efficiency of the details is worthy of the boldness of the conception."

Its site across the Severn was judiciously chosen, and such is its utility that now a thriving town named Ironbridge has sprung up around it on that which was formerly waste land; "and it is probable this bridge will last for centuries to come," adds the author of "Lives of the Engineers:" "thus also was the use of iron as an important material in bridge-building fairly initiated at Coalbrookdale by Abraham Darby, as the use of iron rails was by Richard Reynolds. We need scarcely add that, since the invention and extensive adoption of railway locomotion, the employment of iron in various forms in railway and bridge-structure has rapidly increased, until iron has come to be regarded as the very sheet-anchor of the railway engineer."

When the Government, in 1784, proposed to levy a tax on pit-coal, Richard Reynolds urged upon Mr. Pitt, then Chancellor of the Exchequer, and upon George Lord Gower, afterwards second Marquis of Stafford, the extreme impolicy of such a barrier to progress.

In that year sixteen "fire-engines," as those of steam were then named, were at work in the Dale, eight blast-furnaces, and nine forges, in addition to air-furnaces and mills at the foundry; and these, with the levels, roads, and twenty miles of railway, gave work and food to a vast number of people. Reynolds did not wish it to be understood that he sought for any special protection for home-made iron, notwithstanding the low price at which it could be imported from Russia and from Dannemora in Sweden. "From its most imperfect state as pig-iron," he remarked to the Earl of Sheffield, "to its highest finish in the regulating springs of a watch, we have nothing to fear if the importation into each country should be permitted without duty." The nobleman he addressed on this occasion was that Earl of Sheffield who was President of the Board of Agriculture, and well known in the literary world as a writer on political economy; and the subsequent history of the iron trade has fully justified the anticipations of Reynolds.

When the latter became more advanced in years, he began to long for retirement; he had no desire to possess wealth, yet it had flowed upon him, and he resolved to relinquish his shares in the iron-works at Ketley to his sons, William and Joseph. The former, a man of science and an excellent mechanic, was the first to employ inclined planes, consisting of parallel railways, to connect and work canals of different levels; and Telford, the engineer, handsomely acknowledged the great assistance he received from him in planning the iron aqueduct by means of which the Llangollen branch of the Ellesmere Canal was carried across the Dee at the height of 126 feet above a deep ravine through which the river flows at the width of 2,600 feet. The necessary coilings were all made at the Ketley works.

In 1804 Richard Reynolds finally left the scene of his long labours in busy Coalbrookdale, and returned to his native town of Bristol. There he spent the close of his years in works of charity and benevolence; and though a rigid Quaker, he was fond of painting, poetry, and music. "Many were the instances of his princely, though at the time unknown, munificence. Unwilling to be recognised as the giver of large sums, he employed agents to dispense his anonymous benefactions. Thus he sent £20,000 to London to be distributed during the distress of 1795. He had four almoners constantly employed in Bristol finding out cases of distress, relieving them, and presenting their accounts to him weekly, with details of the cases relieved."

In the eighty-first year of his age, this good old man died at Bristol, on the 10th of September, 1816, and was followed to his grave by the poor of the city, while clergymen of all denominations joined in the remarkable procession. His obsequies were celebrated in the peculiar but unobtrusive manner adopted by the Society of Friends.

MAP AND PLAN DRAWING.—I.

By C. C. King.

DIFFERENCE BETWEEN MAPS AND PLANS—SHAPE OF THE EARTH—PROJECTION OF MAPS—TRIANGULATION.

Map or plan drawing is the delineation on paper of any part or parts of the earth's surface. The term *map*—derived from the Latin *mappa*, "a cloth," probably because maps were originally drawn for convenience' sake on this material—should be, strictly speaking, confined to a representation of an extensive tract of land, when it is called a terrestial or geographical map; but should the area consist chiefly of the sea or any other large space of water, its delineation is termed a hydrographical map or chart. When we simply endeavour to depict on paper any small area which would not, on account of its size, be materially influenced by the curvature of the earth, then we designate it a plan, that is, anything drawn upon a plane.

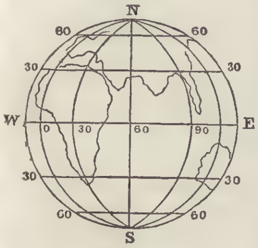


Fig. 1.

Maps and plans, therefore, as terms, are questions of degree, the former applying to large areas, the latter to smaller ones. Thus we speak of the *map* of England or Europe, the *chart* of the Atlantic Ocean or the Bristol Channel; but the *plan* of an estate, a village, or a house. A survey of a county is also a map; but as this under ordinary circumstances enters into very careful detail, and depicts with great accuracy, not merely the more important, but also the minor features of the district, it is entitled a topographical map, that is, one describing minutely all the natural and artificial peculiarities of the ground.

The object of all map-drawing is to exhibit the character of the country or countries, their boundaries, and the positions of their towns, villages, or great physical features, with such accuracy that they shall bear on our delineation both the same relative proportions and the same relative distances apart as they do on the actual globe. This is simple enough if the figure on which the copy is made is similar in form to that whence the copy is taken, the difference between the two being only one of scale. That is, it is easy to portray the surface of the earth on a similarly constructed sphere. But to lay down all the distances and details on the plane represented by our paper, so as to give them all their relative values, is a matter of considerable difficulty, and hence various methods have from time to time been devised to enable geographers to picture with accuracy the surface of the world.

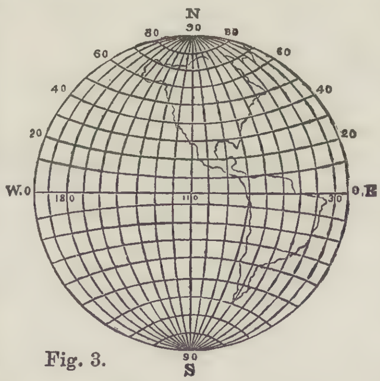


Fig. 3.

The shape of the earth is a sphere, or more properly speaking, an oblate spheroid; and for the convenience of geographical description its surface has been assumed to be intersected by a series of equidistant circles parallel to the equator, called *parallels of latitude;* and again by great circles passing through the poles, and dividing the equator into 360 equal parts, or geographical degrees. These are designated *meridians of longitude.* The geographical latitude and longitude, therefore, of a place are the co-ordinates which fix its true position upon the terrestrial sphere; and for the purpose of this determination the meridians of longitude are numbered from 1 to 180 east and west of that which is assumed to pass through Greenwich in English maps, and the parallels of latitude are enumerated north and south from the equator from zero to 90 at the poles. Other meridians and parallels for every intermediate minute and second of each division or degree are supposed to exist, though they are not drawn, and thus the position of any place on the earth's surface can be determined relatively on the map.

It must be remembered that in depicting any country or area, it is first necessary to construct, so to speak, a framework or scaffolding to which the relative positions of the physical or artificial features can be afterwards referred; and as this framework is represented in map-drawing by the meridional arcs and the parallels of latitude, the first aim of the draughtsman is to determine their position accurately on his paper. Having these carefully indicated, he can trace without difficulty the country he desires to portray; the exact position of any points he may afterwards select as centres, whence to extend the examination of the ground, being readily determined by the intersection of the meridians and parallels of latitude passing through them.

There are three methods of accomplishing this—(1) by projection; (2) by Mercator's projection; and (3) by the method of development. These various methods we shall now proceed to explain in detail, as fully as the space at our command will allow.

Projection is practically a means of representing in perspective the circles of latitude or longitude, and contains further three different plans for arriving at this result—viz., orthographic, gnomonic, and stereographic or central. They all labour, however, under the same disadvantage—clearly exemplified in the maps of the Eastern and Western Hemispheres found in the commencement of every atlas—that of distorting somewhat those parts of the area which lie towards the outer portions of the circumscribing circle. They are, therefore, rarely used, except in the cases above mentioned; and it will be sufficient merely to point out briefly the principles adopted in their construction.

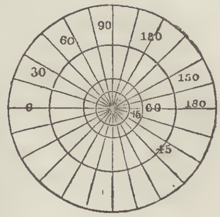


Fig. 2.

The orthographic projection assumes the eye of the observer to be at an infinite distance from the plane which, interposed between it and the sphere, is to receive the projected copy, and hence the visual rays to the various points are parallel to each other, and also perpendicular to the plane, which is technically called the "primitive." The result is to produce a representation of the world in which the meridional arcs are elliptical in form, having the meridian of Greenwich as the major axis, and the radius of the circle multiplied by the sine of the longitude as a minor axis; while the latitudinal arcs are shown by straight lines, the distances of which from the equatorial arc are determined by multiplying the radius of the circle by the sine of the latitude, and measuring them off on the first meridian north and south of the equator. This projection is usually made on the plane of the equator, or that of a meridian (Fig. 1).

The gnomonic or central delineation assumes the eye of the observer to be at the centre of the sphere, and is most commonly employed to depict the regions around the pole, when it is termed a "polar projection." In this case the meridional lines radiate at equal angles from the pole, and the parallels of latitude become concentric circles, whose distances from the pole are = radius × cot. latitude (Fig. 2).

The stereographical projection is used in most atlases to show the Eastern and Western Hemispheres, and it is supposed that the eye is situated on the surface of the sphere, which is considered to be a transparent solid, the plan being made on a plane at the opposite extremity of the diameter. All the arcs in this instance, except the central meridian and the equator, take the form of circles or portions of them (Fig. 3).

These systems are only applied in laying down a hemisphere or any large portion of the sphere, and are, therefore, not applicable to the circumstances under which maps are usually constructed. Reference to any atlas will show how much the shape of the continents is distorted, and this would naturally render these principles of projection of but little use where careful regard to relative proportion, especially in small details, was essential.

The first attempt to describe the earth's surface as a plane was made by Gerard Kauffman in 1512, and is called Mercator's projection, but the principles on which it is based were not fully explained till 1599, when Mr. Wright of Cambridge

examined them and made an exposition of them in his "Correction of Certain Errors in Navigation."

He depicted the surface as a true plane on which the meridional and latitudinal arcs were drawn as parallel straight lines respectively at right angles to one another. The former are equidistant, but by a mathematical rule the latter increase in distance as the latitude increases, in the same proportion as the lengths of the degrees of longitude on the respective parallels of latitude on the map are increased, owing to the fact that the meridional lines are represented as parallels instead of as arcs of great circles meeting at the poles. On the *sphere* the degrees of longitude measured on the parallels of latitude decrease in proceeding north or south; but on the *map* they are the same, on account of the parallelism of the meridians, so that it is necessary to make the distance between the lines representing the latitudes such that the same relative proportion between the length of a degree of latitude and one of longitude at any given point shall be the same on the map as on the sphere—in fact, that the bearing and distance of one place from another on both map and globe shall correspond (Fig. 4).

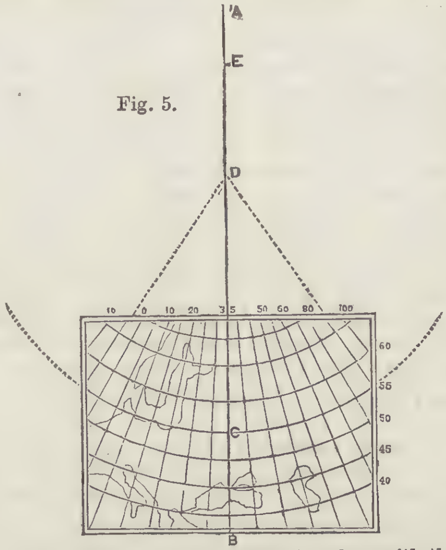


Fig. 5.

The method of development is the principle on which all ordinary maps are constructed, and it will therefore be desirable to examine it more carefully. There are many different plans of development, such as globular, cylindrical, and conical, but they are all similar in their principle—that of representing the earth on such a geometrical figure that it will not be altered by being unfolded or developed as a plane. A sphere cannot be thus developed without destroying it; but a cone or cylinder can be unfolded without altering the value of anything described upon its surface.

The conical method is most generally adopted, and it assumes the surface to be mapped to be a portion of a cone whose vertex is somewhere in the prolongation of the pole, and which either touches the sphere in a circle which is the middle parallel of latitude of the country to be delineated, or falling within the sphere at this circle passes without it at its extreme parallel. The surface of this portion of the cone when developed or unfolded forms the sector of a circle, and pictures with great accuracy the area to be examined (Fig. 5).

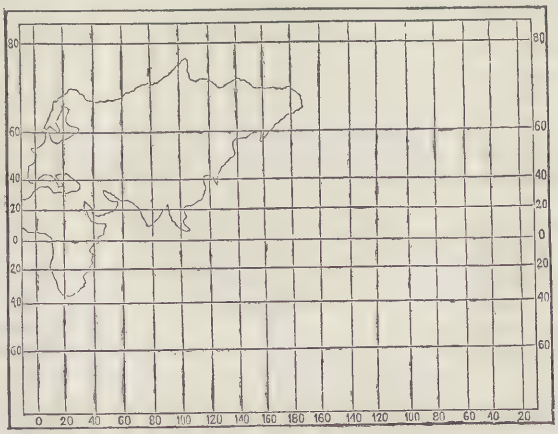


Fig. 4.

The method of describing it on paper is as follows:—

Draw any line A B for the central meridian of the map, and take the point C as a convenient position for the central parallel of latitude. Divide A B into any large number of equal parts, each of which is, on a chosen scale, to represent the degrees and minutes of latitude. Assuming the equator to be divided into 360 equal parts or degrees, this will give the radius of the terrestrial sphere as 57·3 of these, which measure from C to E. Take C D = the cotangent of the middle latitude of the plan reduced to a radius of 57·3 of the degrees of latitude already marked.* This point D will give the centre whence the arcs of latitude will be described through the points on A B. Divide the arc now described through the point C into equal parts, such that the length of a degree of longitude (the division required) : the length of one of the degrees of latitude already described : : cosine of the middle latitude : the radius. Connect these points with the centre D, and the meridians for the given area are obtained.

We have now on paper a relatively correct representation of the meridians and parallels of latitude of the country we are going to map, and we can definitely fix the position of any point on it by its latitude and longitude, and thus obtain a starting-point for the further delineation of the ground. The principle on which all surveying is based—whether the more accurate representation undertaken by a state to show the boundaries of its territories, with its towns and villages, or the simpler topographical maps for military or statistical purposes—is that of uniting all the important points, physical or otherwise, on the area by a system of triangles commencing from a carefully measured base, which forms the side of the first triangle. These are further intersected by a network of smaller triangulations, which will fix all the secondary points on the surface, and finally the details of the ground are completed by measurement and the theodolite, or by sketching them with the aid of some other portable instrument. The degree of care with which this is done depends both on the scale to which the drawing is made, and the purpose for which it is intended. Thus, a military plan or map showing physical details on a large scale, made on actual service, is, though sufficient for the purpose for which it was designed, not essentially extremely accurate, though it may be made so if much time is provided for its construction.

It is evident that the value of this work of triangulation lies in the exactitude of the base-line, and the determination of the true position of the starting-point at one of its extremities. Extreme care in measurement, and a most painstaking repetition of observations are essential, for errors committed at this period of a survey are not merely continued but increased as the work proceeds. With such nicety has this determination of the base-line been conducted in the trigonometrical survey of England, that we find that a base measured on Hounslow Heath in 1791, was on re-measurement proved to coincide exactly in its mean length with the calculated dimensions assigned to it by a triangulation starting from a different base. A still more startling instance of the degree of accuracy which can be arrived at, is that of the measurement of a "base of verification" in Ireland, when, after carrying the triangulation across St. George's Channel, the distance between two points on either side of one of the Loughs was trigonometrically calculated. On measurement it was discovered to differ by only some two or three inches from this calculation.

The value of precision in the determination of a base-line is

* This is readily done by means of the sector. Open the arms of the instrument until the distance between the points marked 45° on the line of tangents (described by T) is equal to the given radius C E. The distance between the points denoting the angles on the line of tangents whose *tangent* is to be found will give the required radius for describing the arcs of latitude. It may be mentioned that the cotangent of the middle latitude is = *tangent* of (90° − middle latitude), and that this tangent is the one employed in finding the radius from the sector.

evidently most important, and whether in an extended survey or a rough sketch or reconnaissance, it should be fixed and measured with all the care that can be bestowed on it. Time is never lost by so doing.

The ground selected for it should be as extensive as possible, and should admit of a large series of prominent points and objects being seen from both ends of it. The more level it is, the more carefully can the base be measured, and the less necessity will there be for reducing it to an accurately horizontal plane. Having chosen an area that fulfils these requirements, one extremity of the base is accurately fixed by observations giving its exact latitude and longitude, and thus we have not merely a known point of departure on the terrestrial sphere, but are enabled to mark it definitely on the projected delineation of the surface we propose to transfer to paper.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VIII.—NATIONAL MUSEUMS (*continued*).

1. *The New British National Museum of Natural History.*—Eight years after the date of that final estimate of space required, from the data herein contained, the Premier and the Chancellor of the Exchequer declared, on the annual report and estimates of the officers of the British Museum being brought before Parliament, May, 1870, that it was the intention of the Ministry to carry into effect, without any further delay, the erection of new buildings to contain the natural history collections, and so ease the other departments of the British Museum from their present engorged condition. This museum is now (1876) approaching completion, and has been erected on the site of the Great International Exhibition of 1862, at South Kensington. The building will be admirably lighted, the windows being large and close together, as is requisite in an edifice devoted to such purposes, and it will form one of the handsomest structures of which the metropolis can boast. According to an official plan of the Gore Estate published in the Report of 1862,* the ground on which it stands consists of $16\frac{1}{2}$ acres, giving a clear parallelogram of 1,100 feet long by over 550 feet wide.

In the Report of 1860 it was stated that while land immediately adjoining the British Museum could not be obtained under £50,000 per acre, the Commissioners of Her Majesty's Commissions of the Great Exhibition of 1851 were willing to dispose of their land on the Gore Estate for such a purpose at £10,000 per acre. In consequence of the great delay, the value of the land, it is asserted, has been increased, by the interest that has accrued through the land standing vacant so many years since that offer was made by one Government department to another.

The objection that was in former days raised against a site at South Kensington, as too uncentral a position for the convenience of a large portion of the inhabitants of London, is removed by the completion of the outer circle of the Underground Metropolitan Railway system, so that it is really more easily accessible to those in the outskirts of the metropolis than to those living in its centre, though the various means of access may be regarded as tolerably well equalised for all.

In 1860 Mr. Panizzi stated that the average number of visitors to the exhibited collections at the British Museum was considerably over 2,000 a day, and it may be noted that the average attendance at the International Exhibition of 1871 was over 8,000 daily. What would have been the number finding their way to South Kensington daily, had that Exhibition, as in the case of the British Museum, been open to the public gratuitously? The South Kensington Museum has also been visited by vast numbers of people.

2. *Classes that National Collections have to provide for.*—*First* for consideration are the working scientific and artistic students, who would consult the various specimens collected and arranged for their use, in the same way as the literary students avail themselves of the books in our public libraries, under suitable regulations; *secondly*, technical students, who by examination of the specimens and attendance at lectures and demonstrations, wish to make themselves practically acquainted with the materials they employ in their trades or professions; and *thirdly*, the mass of the public, who merely visit such museums to pass the time, and find amusement. Of the lower order of visitors, Dr. Gray says that on the public days and holidays they stream quickly through the rooms without evincing any intelligent interest in what is set before them. Of this type I recently came across a very fair example in the mineralogical gallery of the British Museum. A boy was attracted by the brilliancy and brightness of colour of the sulphur group. "What's these, mother?" he inquired of a woman whose rotund body and equally rotund basket indicated materialistic rather than scientific tendencies. "Them's curosites, my dear," she replied; and this probably is an average conception of a large portion of the wage class who do their "outing" at our public museums. On the other hand, Dr. Gray also testifies to the intelligence of hundreds who come from the north, east, and south of London, especially from Spitalfields, with specimens of eggs and insects to compare and name. With this class the collection of British zoology is the most popular in the Museum. Professor Maskelyne speaks of the intelligent observations he has heard made by men of the working class on specimens arranged in his department. Mr. Robert Hunt and Professor Huxley testify to the intelligence and attention of the working men who attended the evening lectures at the School of Mines, and the latter observes in his evidence given before the Committee on Public Institutions,* "Even in difficult arguments they follow the whole case, and show the most perfect possession of the facts, by the questions they ask at the end of each lecture." This class, it should be noted, prefer consulting specimens displayed to the public, and rarely like to trouble the keepers with a request to consult the unexhibited collections in the private studies. A great number of teachers bring their pupils to see the collections. The experiment of opening the Museum late on Saturday afternoon did not prove successful, the number of visitors only averaging 500, instead of 2,000, on that day, but this may have arisen through it not being so generally known that Saturday had been made a public day, as on Mondays it has been densely crowded by the wages classes.

3. *Distribution of the Collections.*—To meet the requirements of the three classes herein specified, we find a generally recognised conviction that the working or scientific naturalists could best be accommodated in private studies, where every facility should be given for examining, and in suitable cases handling, the preserved skins, preparations, osteological specimens, herbariæ, minerals, etc. These studies should also form the store-rooms for all specimens least suited for public exhibition that can be packed away with great economy of space in the drawers and trays of cabinets, or in store-boxes, and should be in immediate communication with such portion of the public galleries as may be devoted to the same class of objects, also with the rooms set apart for the keepers of that class. In the studies should be stored what may be called *author's types* (in contradistinction to the term *typical forms* and *typical species*): these are the absolute specimens employed by an author when describing in book or periodical the natural history characters of an object. Thus the fishes in Yarrell's collection at the British Museum are the author's types, as connected with his standard work on "British Fishes;" such types, Dr. Gray observes, "are neither intended nor adapted for exhibition." In the studies should be kept, in preference to a central library, all books of reference, memoirs, papers in periodicals, etc., connected with the class of objects to which such rooms are devoted. At the British Museum "the books cannot be brought to the specimens nor the specimens to the books." A scientific library may be useful without specimens, but not a collection of natural history specimens without books. Both Dr. Gray and the late Sir William Hooker testify to the advantage of working over show specimens for determining natural history characters. Thus unstuffed skins, disarticulated skeletons, and dried plants, may then be placed in the student's hands with little fear of injury, and in that condition occupy a minimum of space. Dr. Gray states that a collection of birds

* Parliamentary Papers, 1864, Vol. XXXII.

* Parliamentary Papers, 1860, Vol. XVI.

equal to that in the Avian Gallery of the British Museum (300 feet by 50), occupying wall-space equal to 13,500 feet, may be stored in boxes in a room having no greater area than 900 feet; that the collection of insects is kept in cabinets in a room having an area of 1,500 feet, but if displayed in table cases would require a superficial area of 65,000 feet; that the Cumming collection of shells, the most complete in the world, only occupied two small rooms in a private house, but if displayed, would require a gallery "quite as large as that in which the birds and shells of the Museum are at present exhibited."

The class of technical students is only represented in this country by those who have attached themselves to the School of Mines, though we have a Museum of Economic Botany at Kew, and the germ of a Museum of Technical Zoology in the Food Collection at South Kensington Museum. But this class requires something more than a museum: it needs a teaching staff also, and a separate existence from a purely Scientific National Museum of Natural History. As there are professors of chemistry, physics, applied mechanics, mechanical drawing, mineralogy, mining, metallurgy, and zoology, with suitable illustrative specimens, models, etc., might not the sphere of this establishment be extended, so as to include instruction on botany, together with technical botany and zoology? If it has been determined to remove the entire teaching staff of the School of Mines to the new "Science Schools" at South Kensington, why might not this extension of its original sphere of action be made at a time so favourable for re-organisation? The mutual proximity of the scientific and economic collections is an obvious advantage. Whether the technical illustrations of the Kew Museum should be removed to London is a question that ought to be calmly discussed in the mutual interests of technical students and botanists generally. The Food Museum in the South Kensington Museum is on the spot to be utilised to the greatest advantage by the professors of the Science Schools, or of the Technological Museum, under whatever authority it may be placed.

The third class for which the directors of a National Museum have to provide—viz., the general public—is that which requires the greatest consideration, as to the best means of silently conveying information on the general structure of natural objects, their place in the scheme of Nature, and the "life-history" of living forms, in the most attractive manner. This series ranging from the mineral to man would, together with the specimens kept in store in the studies, embrace the entire *classified collection of natural forms*, mineral, vegetable, or animal; but beyond this, there should be an *introductory collection*, which should include specimens, models, diagrams, etc., to illustrate the terms used in defining the external and internal characters, parts, and forms of minerals, plants, and animals, and those epitomes of the characteristics of the great divisions of the mineral, vegetable, and animal kingdoms that are known as "type forms," such as are defined in Huxley's "Introduction to the Classification of Animals," and Rolleston's "Animal Forms," both but recently published. At the present time the specimens in the British Museum are jumbled, vertebrates and invertebrates in the same room, as birds and shells, mammals and corals, reptiles and crustacea. With ample space at command all naturalists advocate a progressive series extending from the simplest inorganic crystal up to the highest organised animal—man, but that only a selected series need be exhibited publicly, which it has been the fashion to term a "typical collection;" but as Professor Owen very justly observes, "Those who are the loudest in advocating the restriction of exhibited specimens to 'types' have contributed least to lighten the difficulties of the practical curator in making the selection," and very pertinently raises the question as to what species should be selected as *the* "type" in various groups of the animal world he specifies. Others term what is aimed at as the "representative" system of arrangement. It is agreed that a national zoological collection should include the male, female, and young at one or more stages of maturity, the skeleton of the same, or parts thereof, winter and summer coats, plumage, eggs, nests, etc., of vertebrates, the metamorphic phases of invertebrates, every known variety of species obtainable (of vast importance in connection with Darwinian views), monstrosities, and distorted forms, etc.; but Professor Owen speaks of exhibiting only a portion of such treasures to public gaze, in which the curator must be guided "by the principle of selection." The fact is, the problem has never been worked out, as to what really is essential for public exhibition in a National Museum; but the change from Bloomsbury to South Kensington will give an opportunity for exercising the judgment of our practical curators, in determining what specimens, under what arrangement, would best represent in "Life-history Groups" our existing state of knowledge on natural history, and in such a manner as to make that other revelation of the Deity, "THE BOOK OF NATURE," written in stone tomes, on the leaves of plants and on the skins of animals, readable by the masses of the people.

TECHNICAL DRAWING.—LXIX.

DRAWING FOR BRICKLAYERS.

FLEMISH BOND.

FLEMISH bond implies brickwork so arranged that the bricks in every course present the appearance of a header and a stretcher alternately, from one end to the other, and in successive courses. Every header is placed over the centre of a stretcher below it. Closers are placed next to the corner headers in alternate courses in the manner and for the purpose already explained.

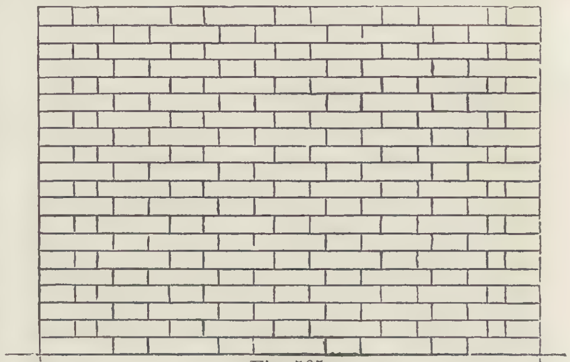


Fig. 565.

Fig. 566.

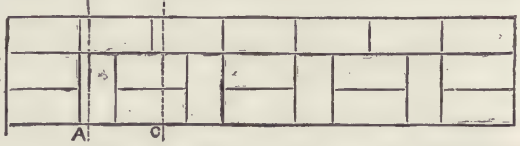
Fig. 567.

The appearance of a wall built in Flemish bond is therefore that shown in Fig. 565.

We again adopt as our illustration a portion of a wall equal

Fig. 570.

Fig. 571.



to seven bricks in length, one brick thick, and terminating with perpendicular ends. Figs. 566 and 567 are the plans of two successive courses of such a wall, and Figs. 568 and 569 are sections on the lines A B, C D.

It will be evident that in this wall both sides will be alike; but in walls of greater thickness two different arrangements may be adopted, called *single* and *double Flemish bond.*

SINGLE FLEMISH BOND.

In a wall built in what is called single Flemish bond, the bricks are so placed that whilst Flemish bond is seen on the

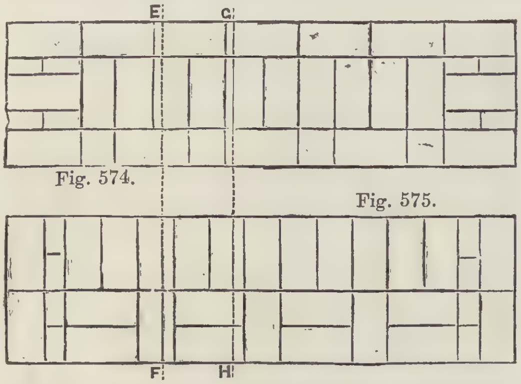


Fig. 574.

Fig. 575.

one side, the bond on the other is English, which arrangement is only applicable to walls of more than one brick in thickness.

In such cases the Flemish bond, as being considered the most pleasing, appears, of course, on the face of the wall, or external surface of the building, which is eventually the only side generally exposed to view.

Common single Flemish bond is merely a modification of

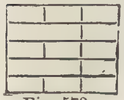


Fig. 573.

Fig. 572.

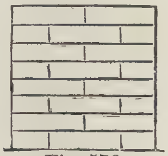


Fig. 576.

Fig. 577.

English bond, which may by some be considered more ornamental, but which is certainly not so strong.

As in English bond, there are in this method heading and stretching courses alternately; the stretching course consists merely in using bats or half bricks, instead of whole bricks, in every alternate course in the face of the wall, as shown in

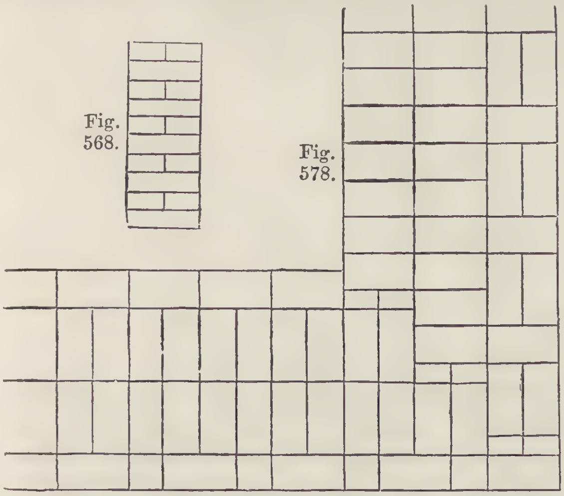


Fig. 568.

Fig. 578.

Fig. 570. In the heading courses real headers or whole bricks are used in the face of the wall, between which every stretcher is backed with a second brick also laid as a stretcher (Fig. 571). With this exception of using double stretchers in the heading courses, the same arrangement is followed as in English bond of filling up all the remainder of a thick wall with headers. The rule of not breaking the horizontal joints is also observed in this method.

Fig. 572 is the section on A B, and Fig. 573 the section on C D of the wall of which Figs. 570 and 571 are the plans of alternate courses, the wall represented being of a brick and a half in thickness.

Figs. 574 and 575 are plans of two successive courses of a wall of the same description, but two bricks thick.

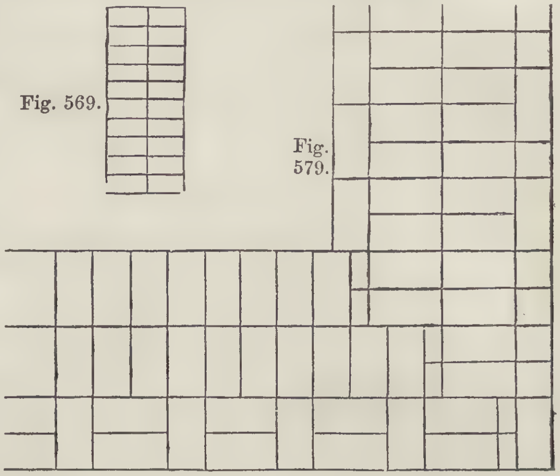


Fig. 569.

Fig. 579.

Fig. 576 is a section on E F, and Fig. 577 a section on G H.

Figs. 578 and 579 represent the plans of two successive courses of the corner of a house in which the walls are supposed to be three bricks thick, built according to the common single Flemish bond, and having the closers checkered in the usual manner.

SANITARY ENGINEERING.—XX.

MOULE'S PATENT EARTH-CLOSET SYSTEM.

In a series of preceding papers we have treated in some detail of the practical methods of dealing with sewerage where water is employed, and where a system of drainage is provided by means of which all soil, as it is specially designated, is washed away. In all these cases, as far as the immediate tenant or occupier of a house or cottage is concerned, the sewage, with its attendant value (no supposititious matter, but one which can be easily calculated and expressed in its equivalent of pounds, shillings, and pence), is removed from the premises by means of the drainage; and unless, under some of the more extended disinfecting processes recently introduced, the entire sewage of a hamlet, town, or borough is otherwise dealt with, the value of all these matters as manure runs to waste.

We have now to explain a totally different set of circumstances. In Moule's earth system water is not only not required, but the presence of more than a certain per-centage of moisture materially interferes with the efficient action of the process. Instead of water being employed to wash away, earth is employed to absorb and deodorise. Practical experience proves that it does this most thoroughly and effectually; and, therefore, the conditions under which a closet has to be constructed are totally different in detail to those given in our preceding papers. It has been ascertained by repeated experiments on an extended scale that about a pint and a half of dry earth thrown on to the surface of a vessel containing what is usually called an ordinary "dejection" is amply sufficient in quantity to absorb all noxious effluvia and ordinary gas products; and the objects of the special patent are the mechanical means adopted to apply this first principle efficiently in the necessary detail.

The dryness of the earth used and its absorbent qualities are the first requisite. Sand, especially of the description called

by architects and engineers "sharp," is useless, because it is non-absorbent; the sharper, in technical phrase, the sand is—the more fragments of quartz or comminuted flint it contains—the more its powers of absorption and deodorisation are diminished, and the less fit does it become for the special object under notice. Dry loam finely powdered, or dry clay in a similar condition, are the materials that should alone be used;

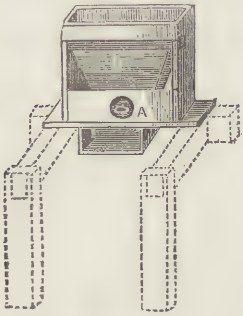


Fig. 30.

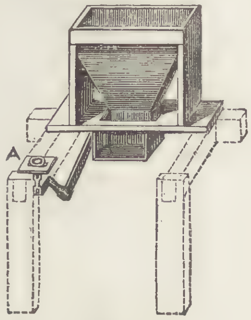


Fig. 31.

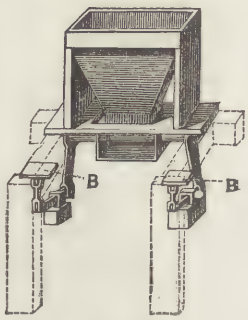
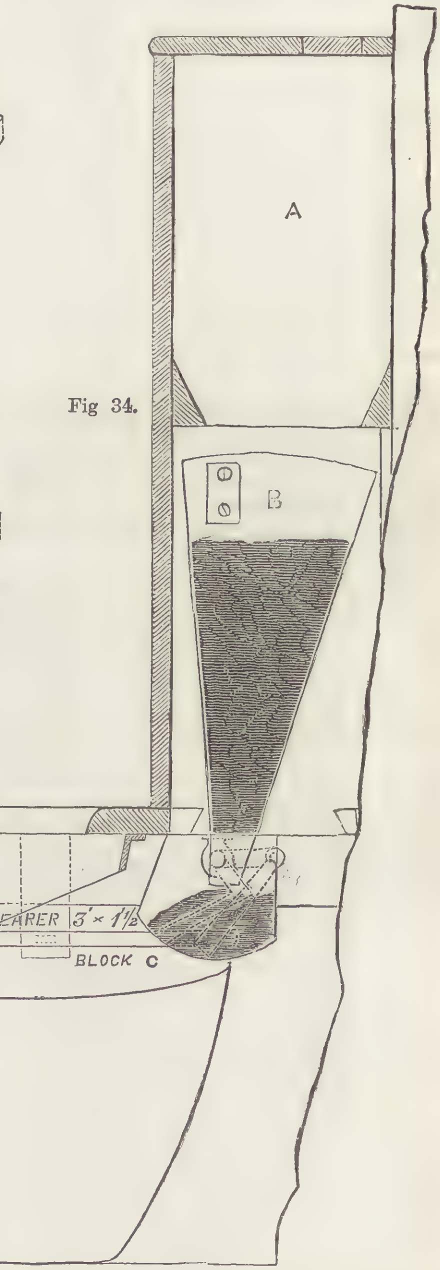


Fig. 32.

Fig 34.



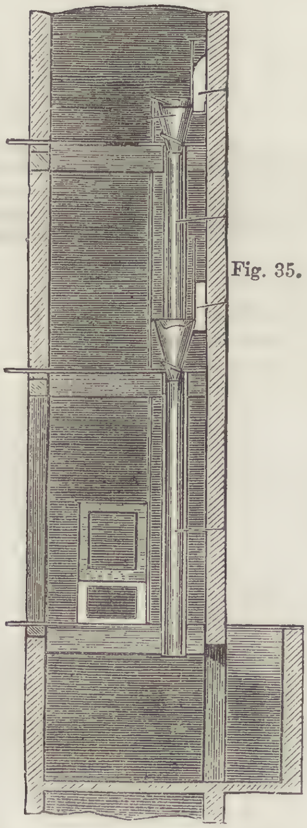


Fig. 35.

and there is this curious feature, that they may be re-dried after each operation, and this without any objectionable result, and when dried used again. This may be repeated continuously, even up to twelve or more times, each time considerably increasing the value of the material as a manure. In the sequel we intend to quote various figures from competent authorities as to the value of the result thus obtained.

The general principle of the patent thus explained—*i.e.*, the employment of earth as an absorbent in place of water as a diluent—we may proceed to say that the use of these closets is legalised by the new "Sanitary Amendment Act," of July 31st, 1868, and that, therefore, there is no statutory reason against their general introduction. It will be evident that in many situations where water is not easily procurable, or where the general arrangements for water-supply, as understood in our metropolitan and provincial towns, are incomplete, their introduction will be attended with advantage. In large and crowded city districts, where there is already a complete organisation under the present system, the same opening does not exist, and difficulties lie in the path of the extended introduction, not on the ground of any defect in the general principle adopted, but arising solely from the fact that the necessary facilities for the rapid removal and utilisation of the resulting products are not at hand.

For small towns, hamlets, and villages with deficient water-supply, of which there are so many throughout the country, the system may be safely recommended, as here not only do the

facilities exist for readily obtaining a supply of dry earth or loam at a moderate outlay, or no outlay at all, but the field for the utilisation of the products lies at the very door, in the garden or the field adjoining.

Having thus dealt with the general principle, we now proceed to detail. The outward appearance of the closet is in construction exactly in accordance with our usual habits; seat, riser, and lid may be taken as identical with those in every-day use; but here the resemblance ends. Instead of the almost endless system of pipes, the cistern, the traps, the valves, etc. etc., usually required, the only requisite is a vessel in the form of a hopper, made generally in galvanised iron, to contain the dry earth, which is the absorbing and deodorising agent. The subjoined sketches will show the form in which it is applied, and the various mechanical working details will now be explained.

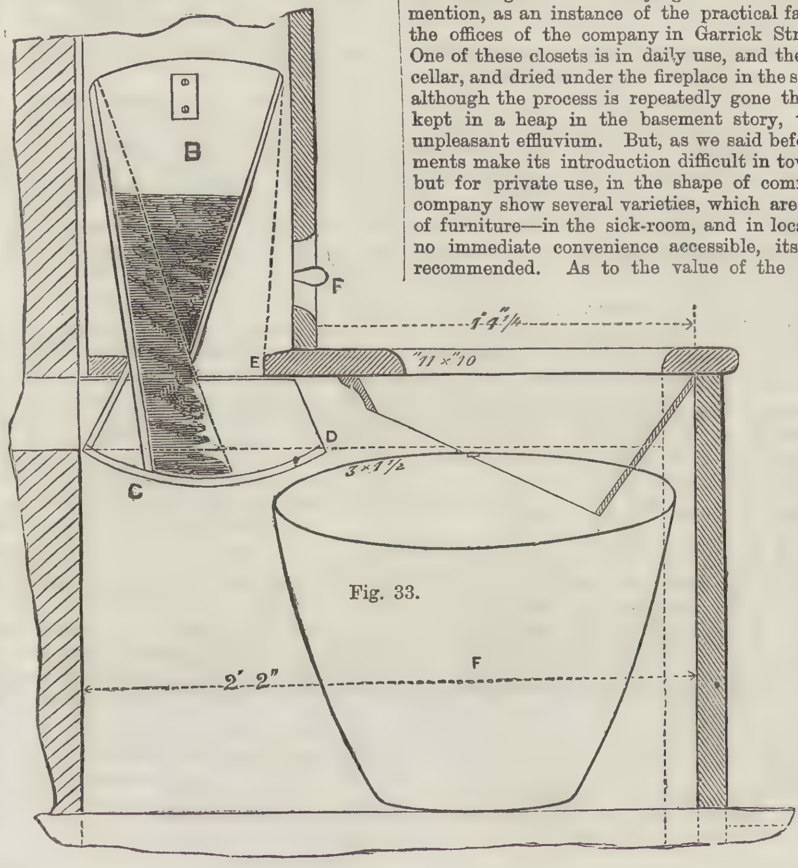


Fig. 33.

Fig. 30 represents the simplest form of closet of this description, showing the vibrating hopper, the handle that moves it, and the bearers that carry the seat and riser of an ordinary closet. The general arrangement, the space required, and the mechanical action, will be explained in some of the following cuts. A is the handle, by means of which the vibrating hopper, B, discharges the requisite volume of dry earth into the receiver below. In Fig. 31 the principle is the same, but instead of the direct pull from the handle the matter is so arranged that by means of a lever an action is obtained similar to that of an ordinary closet. The pull-up handle is at A. Fig. 32 is an adaptation of the same principle to a self-acting closet, as it is technically termed—*i.e.*, one in which, by the hinged action of the seat itself, by the simple weight of the body, the same result is obtained as by the simple handle (Fig. 30) and the pull-up action (Fig. 31). B, B are the plates attached to the seat, which, rising by a self-acting motion when relieved from weight, discharges the requisite quantity of dry mould by the methods we shall now describe.

In the section in Fig. 33, B shows the hopper containing the dry earth, with the handle, as shown in Fig. 30. When the handle is pulled the vibrating hopper is moved forward to the dotted line indicated by the point E, the bottom edge traversing the line from C to D, and discharging the certain quantity of loose earth into the receiver, F. On the handle being pushed back, a fresh charge of earth falls from the hopper, and it may be used again immediately.

We next give another arrangement of the same kind (Fig. 34), in which the vibration given to the hopper is only a quarter of an inch, with a view of loosening and shaking down the dry earth, the discharge into the receiver being made by the "chucker," as it is called, fixed at the lower mouth of the hopper. The shaded lines show the position of the earth when the closet is at rest, and the dotted line at point C indicates the extent of the motion of the chucker, which resembles in its action a hinged scoop. In this case an arrangement is also shown by which a fixed reservoir, A, is provided above the hopper, B, which can be filled with earth at stated intervals, thus keeping the hopper supplied.

Having, then, in the preceding remarks practically illustrated the matter in hand, we will now proceed to give one or two cautions as to the use of these closets.

1. The earth must be dry and sifted.
2. One charge must always be thrown into the receiver before use.
3. No slops must be thrown down.
4. In every case, either with pull or handle, or self-acting, the action should be given with a jerk, so as to throw the earth freely forward.

With regard to the drying of the earth after use, we may mention, as an instance of the practical facility of the process, the offices of the company in Garrick Street, Covent Garden. One of these closets is in daily use, and the earth is kept in the cellar, and dried under the fireplace in the show-room itself; and although the process is repeatedly gone through, and the earth kept in a heap in the basement story, there is no trace of unpleasant effluvium. But, as we said before, existing arrangements make its introduction difficult in towns on a large scale; but for private use, in the shape of commodes—of which the company show several varieties, which are really elegant pieces of furniture—in the sick-room, and in localities where there is no immediate convenience accessible, its use may be safely recommended. As to the value of the resulting manure in country districts, Mr. Gadsden, who farms 600 acres of land in the neighbourhood of Halton, "has no hesitation in estimating its minimum value at £3 per ton." Mr. Taylor, of Dorchester, a manufacturer of agricultural implements, and a manure merchant, supplies the earth for the closets and urinals of the Dorset County School, and he considers the value of the manure, when used but once in the closet, to be worth £2 to £3 per ton. He also considers that it increases in value in proportion to the number of times it passes through the closet. Similar opinions may be quoted in great numbers.

As instances of the practical use of the principle on a large scale, we may quote the Camp at Wimbledon, Broadmoor Criminal Lunatic Asylum, the County School at Dorchester, and many others. Under date 11th of July, 1867, the Government authorities of India write: "Not only has Mr. Moule's system been very generally adopted, but it has been found to be a public benefit of great value." Into the details of its application to urinals, public and private, slops, kitchen waste, and foul water generally, our space will not allow us to go. We conclude with an illustration (Fig. 35) showing how this principle can be adapted for use on different storeys and at different levels, and the products received in a vault in the basement. Our readers who are familiar with drawings will readily understand the illustration without our explaining the details.

For every and all situations, or to supersede our present method of flushing and water-supply, it would be Utopian to recommend the earth-closet system; but we may say, without hesitation, that under many conditions its introduction would be attended with manifest advantage to the public.

MINING AND QUARRYING.—XXIV.

BY GEORGE GLADSTONE, F.C.S.

LEAD.

SUPPLY OF ORE—GENERALLY ARGENTIFEROUS—GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION—AGE OF LEAD WORKINGS—CHARACTER OF LEAD VEINS—DRESSING THE ORES—ASSAYING.

In the mining and metallurgy of lead, Great Britain takes the first rank amongst the nations of the world, about one-half of the entire supply of this metal being the produce of the British Islands. While speaking of lead too, it is impossible to pass unnoticed the remarkable fact that silver, in greater or less quantity, is almost, if not always, associated with it; so that although silver mining as a distinct operation does not exist in this country, Britain ranks second only to Spain among the nations of the Old World in respect of the production of this precious metal.

It will be impossible, therefore, in speaking of lead, to avoid frequent reference to silver, though the writer will endeavour to keep the two subjects as distinct as possible.

It seems now to be conclusively established that gold also is always associated with lead, though in such small quantity as rarely to be worth consideration.

There is but one ore of lead which is of commercial importance, the sulphide (PbS), commonly called galena; and the metallurgic processes we shall describe will therefore relate to this ore alone, though many other combinations exist in Nature. The latter are interesting rather as mineralogical specimens: they never occur in England in sufficient quantity to render any special metallurgical processes necessary. The commonest of them is cerussite or lead spar, which is a carbonate of lead, forming large, transparent, and generally colourless crystals, or sometimes fibrous or earthy masses. The sulphate occurs in spots where the sulphide has been affected by the action of the weather, but where no carbonate of lime has been present to convert it into the preceding. The carbonate accordingly is generally found where the lodes of galena occur in the sedimentary limestone rocks, and the sulphate in the older argillaceous deposits. The phosphate and arsenate of lead are frequently associated near the outcrop of the lead veins.

Galena occurs in this country principally in the clay slates and limestones ranging from the Lower Silurian to the Carboniferous formation inclusive. The latter rock has hitherto supplied about two-thirds of the entire produce of the British Isles, though recently some very rich deposits have been opened up in the Lower Silurian rocks of Montgomeryshire and Cardiganshire. Thus the great lead district of the North of England, of which Alston Moor is about the centre, lies in the Carboniferous limestone; that of Derbyshire in the same. The long-wrought Welsh mines, which are also remarkably rich, are partly in the Carboniferous limestone and partly in the Lower Silurian slates; those of Devonshire and Cornwall are in the killas or clay slate of the Devonian age; those of Lanarkshire and Dumfriesshire in the same; those of the Isle of Man in Silurian limestones; whilst the Irish form an exception to the rule, and are chiefly in granitic rocks.

On the Continent there are large deposits in Germany, Sweden, Spain, France, and Greece. Some of those in the two former are, however, so remarkably rich in silver, that the mines are actually worked principally for the sake of the latter metal; the lead, though of course far greater in bulk, being, as it were, only a secondary product. A very large district in the United States of America is rich in lead ores, and as the population increases in that region (extending both westward and southward from Lake Michigan), the working of these is attracting increased attention; the day indeed is probably not far distant when the United States will be one of the largest lead-producing countries in the world.

The history of lead-mining in this country goes back to a remote antiquity. There is no question that lead was extensively worked by the Romans; reference to its abundance in Britain is not uncommon in their historical writings; many of the old workings are situated in districts which they occupied, and indubitable Roman remains have been found in them. Moreover, pigs of lead of Roman age have frequently been disinterred, and there is even strong evidence that the working of the lead mines has been continuous from that period till now, in the curious fact that the ancient pigs are of the same size and form, and bear the same distinguishing marks as those of the same district in the present day. Lead, too, was very extensively used by the Romans, and they seem to have been well acquainted with a variety of purposes to which it could be applied with advantage. Thus, in visiting the houses of the luxurious inhabitants of ancient Pompeii, the traveller will now find behind the elegant fresco paintings that adorn the walls of the reception-rooms, that a layer of sheet lead has been placed between the brickwork and the stucco to preserve the latter from damage by wet. In our metallurgical processes it is evident that we have considerably improved upon the ancients, so that the refuse slags from their furnaces are often found to be rich enough in metal to be re-smelted with advantage. Thus in some parts of Somersetshire where the ore is not worked now, there are smelting establishments for the sole purpose of using up the refuse from former works; and a considerable portion of the lead now manufactured in Spain and Greece is in like manner derived from what was thrown aside as valueless by the ancients.

The lead mines in this country are rarely of any great depth. Some of those in Northumberland, where the rock is liable to very great throws in consequence of the whin dykes which disturb that part of the country, are 600 feet deep, but they are generally much shallower. One or two of the mines in Devonshire are of considerable depth. On the Continent, however, there are several which are remarkable for their great depth. The Samson mine at Andreasberg, in the Harz district, for instance, is no less than 2,733 German feet deep, while several others in the immediate neighbourhood are of scarcely inferior depth.

The ore occurs in regular lodes, but these are often spread out into what are called flat veins. These are masses of lead ore which have penetrated from the lode itself between the bedding of the limestone; they never extend any great distance from the true lode, but often contain within a comparatively small space a large mass of metal. If a bed of sandstone should part two layers of limestone which is traversed by a metalliferous vein, the portion flanked by the sandstone will be found to be very much poorer in metal than that on either side of it. In Derbyshire and other places a lode is often cut off entirely for a space by the intrusion of a trappean rock; but unless the intruder forms too thick a mass to render it worth the expense, the miner will cut through it for the sake of reaching the lode again on the other side.

The veins of galena are of very various thickness; sometimes they are split up into parallel branches, connected by thin strings or leadings of ore; at other places, as at Hudgill Burn, there is a solid vein seventeen feet thick. The character of the lodes is very similar to those already described under tin and copper; except that the galena is not diffused through the gangue, as in the case of the former. The lead ore occurs in a massive crystalline form, associated with layers of sulphate of baryta (called cawk in Derbyshire), calcareous and fluor spar, in the Carboniferous rocks; and more commonly with quartz in the older formations. The fluor spar is especially prevalent in Derbyshire, and it is valuable in metallurgical operations as a flux.

The general direction of the lodes is east and west; though there are several notable exceptions. Thus at Holywell, in Flintshire, a very strong lode occurs in the cross course; and some of the rich silver-bearing lodes of the Isle of Man also run north and south. In Devonshire several lodes take the same direction, and at the point of intersection with the east and west veins they are usually highly argentiferous; they are rarely found to approach closely to the eruptive rocks as those of tin and copper do.

There are also some deposits of lead ores, principally a mixture of the sulphide and carbonate, not much worked in England, but to a considerable extent on the Continent, which are quite different in their character. They occur, too, in a rock of more recent formation, the New Red or Trias. The copper-bearing stratum of Alderley Edge, in Cheshire, contains particles of lead ore disseminated through it; and sandstones of the same age in other parts of the country present occasionally the same peculiarity. In Rhenish Prussia there occurs a very valuable deposit of a similar character. The sandstone bed is about 120 feet thick, but only some layers of this are sufficiently

permeated with the grains of galena to be worth excavating. In some places it is quarried, and in others the workings are carried underground. At Kommern alone upwards of 1,200,000 tons of the sandstone have been excavated in one year, yielding about 22,000 tons of dressed ore: it is argentiferous, though only yielding a low per-centage of silver.

Lead ore, on being brought to "grass," has to be dressed in order to prepare it for the smelting operations; and the processes which it has to undergo for this purpose bear, at some establishments, a considerable resemblance to those already detailed when describing the dressing of tin ores. It is first sorted and cleaned, in the course of which the lumps of foreign ingredients, spar, baryta, etc., are thrown aside; then it is crushed or ground to a coarse powder, which is usually done now by passing it between a pair of cylinders turning in opposite directions, and driven by water-power. The cylinders are fed with ore from a hopper above, into which the contents of the wagons are tipped as they are drawn from the mine: the hopper is subjected to a slight vibratory motion by the action of the machinery with which it is connected, and this is sufficient to keep up a constant supply of ore to the cylinders, and to prevent the aperture at the bottom of it from becoming clogged. A small stream of water also aids this process, and afterwards passing over the cylinders prevents them from becoming overheated. The latter are made of iron, and are case-hardened; they are not rigidly fixed in their place, so that if a piece of unusually hard material should get between them, the machinery shall not be brought to a standstill or become deranged; but the cylinders will yield place just sufficiently to allow such refractory piece to pass through. If the rock in which the ore is deposited be of a very hard nature, the use of stamps is generally resorted to, in place of the grinding process. The stuff is usually reduced by the crushing mills to a sufficient fineness to pass through a sieve containing nine holes to the square inch, which, when done by water-power, will not cost more than about 2½d. per ton.

After the ore has thus been crushed or ground, the washing takes place, which is performed by passing a stream of water through the ore, in the same way as the tin ores are separated from the earthy ingredients, a description of which will be found in Article XVI. In some foreign countries, especially in such as the Harz district, where the ores are so valuable on account of the silver contained in them, this operation is carried to a very high state of perfection, and the most improved forms of frames are employed; the ores too are there crushed much finer than is usual at English works, or is even thought desirable by our smelters. The very considerable specific gravity of pure galena, 7·6, enables the washers to separate not only the earthy portions, but also most of the metallic substances which may be associated with it: argentiferous ores require greater care in the washing, as the sulphide of silver is of less specific gravity than that of lead.

MINERS IN THE HARZ MOUNTAINS.

The ore being now ready for the smelter, the most ready mode of ascertaining the quantity of metal contained in it is to make the assay in an iron pot instead of an earthen crucible, the metal of the pot assisting in the separation of the sulphur from the ore. The sides of the pot should be about half an inch thick, and the bottom rather thicker still; it should be hammered out of a solid piece of iron, so as to have a smooth interior surface without any seams. Preparatory to charging it, the pot should be put in the furnace and heated to dull redness. It should then be removed from the fire for a moment, and filled with a mixture of ore and flux, the constituents and proportions of which will depend a good deal on the richness or otherwise of the ore to be assayed. Some recommend a mixture consisting of $\frac{4}{11}$ of ore, a similar quantity of carbonate of soda, $\frac{2}{11}$ of pearlash, and $\frac{1}{11}$ of bitartrate of potash, upon the top of which a little borax should be sprinkled. If a rich sample is being operated upon the mixture may consist of equal parts of ore and carbonate of soda, with a tenth part of argol; but for poorer samples, the carbonate of lead should be reduced by about one-third, and its weight replaced by borax. The pot must then be covered down, replaced in the furnace, and heated up to a full red. While at its full heat, the pot is removed from the fire, and the charge poured into an iron mould which has been rubbed over with plumbago and warmed; on cooling, a button of lead will be found at the bottom. The weight of this will give, by calculation, the per-centage of metal in the ore.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XII.

BY E. WYNDHAM TARN, M.A.

In our last two papers on this subject we gave the measurement of dimensions of joiner's work and ironmonger's fittings throughout a small house consisting of a ground floor, first floor, and second floor: in the present paper we proceed to give the abstract of these dimensions. In the first part of our abstract, which appears in its entirety on this page, all the *superficial* work, or work of which superficial measurement is required, is brought together—namely, the floors, sashes and frames, doors, shutters, stairs, etc.; then measurements of skirtings, friezes, dresser-top, etc., which are regulated by the thickness of the deal of which they are made; and lastly, the various fittings which from their conspicuous position, or for appearance' sake, require to be made of mahogany. Following this we next take all the various parts of the fittings in deal and mahogany that are measured by the *run* without reference to length, breadth, or thickness; then we collect together all fittings measured by numbers; and lastly, the ironmongery and fixings. It will be manifest even on the most cursory inspection that the preparation of an abstract of dimensions is a piece of work which requires great care and attention, and as an item may readily be omitted where so many demand consideration, it is almost needless to remark that the work should be checked carefully. For the sake of practice, the student should take the dimensions given under each branch of the building trade in turn, prepare abstracts from them, and then compare those of his own making with the abstracts that we have furnished.

ABSTRACT.

SUPERFICIAL.

FLOORS.	SASHES AND FRAMES.	DOORS.	SHUTTERS.	STAIRS.	¾ IN. DEAL.	1 IN. DEAL.	1¼ IN. DEAL.	1½ IN. DEAL.	MAHOGANY.
2 ct. w. batten folding. ft. 100)217 0 ——— 2 sq. 17 ft. 1½ in. yell. batten strt. jt. ft. 100)187 0 ——— 1 sq. 87 ft. 1½ in. y. tongd. i. tongues. ft. 100)196 2 ——— 1 sq. 96 ft.	Dl. cased frame, o. sk. sill, 1½ in. ov. sash, dble. hg., br. pulleys, w. lines, i. wts. ft. 15 9 Dl. cased frame, o. sk. and weathd. sill, 2 in. dl. lamb's-tongue sash, dble. hg., br. pulleys, pat. lines, i. wts. ft. 22 0 Ditto, ditto, ovolo sash. ft. 29 3 Solid oak rebd. and mo. frame, 4 × 3, mullion and transom, mitred, bd. and weathd. sill, 2 in. lamb's-tongue casement, circr. on plan, ½ in. rise. ft. 35 9 2 in. oak ov. fanlight, circr. head. ft. 7 0	1½ in. 2 pl. sqre. ft. 16 6 1½ in. 4 pl. mo. and sqre. ft. 16 6 1½ in. sqre., 4 pl. ft. 17 11 2 in. mo. b. sides, 4 pl. ft. 19 6 22 9 —— 42 3 2¼ in. oak, 6 pl. boln. mo., lower pl. bd. flush. ft. 26 3	1¼ in. 2 p. bd. fl. and sqre., hg. with br. pulleys, pat. lines, lead wts. ft. 35 9 1¼ mo. and bd. fl. in 2 pl. folding. ft. 15 2 1¼ in. bd. fl., and sqre. bk. flaps. ft. 13 0 1¼ in. ppr. boxings. ft. 10 3 Revolving wood, with worm and wheel gearing. ft. 105 4	1½ in. y. dl. treads, 1 in. risers, glued & blocked to close-string, mo. nosg., 2 fir carriages. ft. 66 0 Ditto, ditto, winders. ft. 19 3 1½ in. y. dl. treads, 1 in. risers, mitred to cut-string, glued and blockd., mo. nosings, 2 fir carriages. ft. 69 11 Ditto, ditto, winders. ft. 17 11 1½ in. rebd. and bd. outer string, cut and mitred to rise. ft. 13 9 Ditto, ditto, writhe. ft. 1 6 1½ in. rebd. and bd. close string. ft. 11 11 1½ in. wall-string. ft. 20 0 15 0 —— 35 0 Ditto, ditto, ramp. ft. 7 0 12 0 —— 19 0	W. 1 s. and framed. ft. 5 8 6 8 9 7 —— 21 11 W. 1 s. and bdd. ft. 2 3 W. 1 s. rebd. and bdd. ft. 8 4 W. b. s. and dovetd. ft. 7 6 W. b. s. and tongd. ft. 14 0	W. 1 s. and tongd. ft. 10 2 17 6 4 0 —— 31 8 W. 1 s. and rebd. ft. 8 9 13 7 15 3 9 7 9 7 4 6 4 10 —— 66 1 W. b. s. frad. and bdd. ft. 3 0 Torus skirtg. ft. 30 5 Sqre. skirtg. ft. 25 8 4 1 —— 29 9 W. 1 s. mo., 1 pl. ft. 7 11 Keyed frieze, jts. feather-tongd., rebd. for soffit. ft. 21 9 W. b. sides. ft. 5 8 6 0 15 0 —— 26 8	W. 1 s. frad. and mo. in 2 pls. ft. 8 3 W. 1 s. frad. and mo., in 1 pl. ft. 9 7 W. b. sides. ft. 3 0 7 7 15 9 —— 26 4 W. b. s. frad. and bdd. ft. 15 0 18 6 5 3 3 6 —— 42 3 W. b. s. cut and dimd. ft. 7 6 Mo. and sqre. framg. ft. 19 0 Ditto, circr. on plan (½ in. rise). ft. 5 0 Mo. and sqre. spandril. ft. 22 9 Mo. and rebd. skirtg. in 2 heights. ft. 53 9	W. 1 s. dble. reb. and bdd. ft. 6 4 6 6 —— 12 10 W. 1 s. dble. reb. fram. and mod. ft. 21 11 2 IN. DEAL. Clampd. dresser top. ft. 18 2 SUNDRIES. Cradling to entab., ploughd. and tongd. blockings. ft. 43 6 Mod. cornice. ft. 24 0	¾ in. w. b. s., Fr. pold. ft. 2 2 1 in. framd. seat and riser, Fr. pold. ft. 11 5 1 bd. flap and frame, Fr. pold. ft. 6 2 1 in. mo. and sqre. framg., Fr. pold. ft. 34 6 1¼ in. counter top, glued and blocked. ft. 25 6 2 in. astragal and hollow folding sash door, dimd. stiles, lower pl. mo. and bd. fl., Fr. pold. ft. 24 6 2¼ in. lamb's-tongue shop sash, Fr. pold. ft. 66 6 Ditto, circr. on plan. ft. 17 6

RUN.

Deal.			Mahogany.
½ in. wrot. stop. ft. 7 0 ¾ in. chamfd. fillet, 2½ in. w. ft. 7 8 ¾ in. skirtg. grds., pluggd. ft. 40 6 ¾ in. bead. ft. 3 6 4 3 ——— 7 9 Sqre. angle staff, plugged. ft. 20 0 23 0 ——— 43 0 Drawer runners. ft. 9 6 Groove. ft. 13 0 21 0 ——— 34 0 Groove and tongue. ft. 48 9 1 in. nosing. ft. 4 6 6 0 ——— 10 6 1 in. picture grds. plugged. 25 0	1 in. skirtg. grds. plugged. ft. 43 0 9 7 ——— 52 7 1 in. dble. bd. pin-rail, 4½ in. w. ft. 4 6 1 in. arch mo., 2½ in. w. ft. 14 0 33 0 4 6 23 6 ——— 75 0 1 in. ar. mo., 3½ in. wide. ft. 5 0 21 6 34 0 ——— 60 6 1½ in. ditto. ft. 23 6 38 0 15 0 ——— 76 6 Ditto circr. ft. 6 6 1½ in. m. border. ft. 13 0 7 0 ——— 20 0 Moldg. 4 in. girt. ft. 9 6 Ditto circr. ft. 2 6	2½ in. wrot. and framd. legs. ft. 12 0 2½ in. turned newell. ft. 15 6 2½ in. mo. hand-rail. ft. 13 0	Mod. nosing. ft. 3 6 ½ in. skirtg., 4 in. w., Fr. pold. ft. 7 0 3 in. mo. hand-rail, Fr. pold. ft. 15 0 Ditto, ditto, writhe. ft. 3 0 Bdd. door frame, 3″×3″, Fr. pold. ft. 18 0 Mortise clamp. ft. 6 0 Headg. joint. ft. 6 0 Wrot. and chamfd. fillet. ft. 3 0

NUMBERS.

Deal.		Mahogany.
Housings to string for flyers. 30 15 18 — 63 Ditto, ditto, winders. 3 3 — 6 Ditto to handrail. 15 Ditto to newell. 3 1 — 4	Mitres to 9 in. skirting. 8 Dovetail blockings. 3 Pendants to newell 2 1¼ in. sqre. baluster. 15 1½ in. turned ditto. 30 Returnd. mo. nosing. 15 Cut bracket. 15	Dished hole. 1 Beadd. handhole. 1 Rod. corner to skirting. 2 Fittg. and hangg. flap. 1 Mitre. 4 ¾ in. quadrant shelf, 9″×9″, on fillets, Fr. pold. 1

NUMBERS (*continued*).

Deal.		Mahogany.
Dovetl. housings for balusters. 30 Rod. corners to shelf. 2 3 1 — 6 Ditto, dresser. 2 O. G. cut ends. 2 Tongd. angles to string. 2 Tongd. and mitred angles to 15 in. skirting. 10	Curtail scroll end to step. 1 Elbow caps. 2 Soffit to boxing. 2	Handrail scroll. 1 Housings in hand-rail. 30

IRONMONGERY AND FIXING.

Hinges.	Locks.	Fastenings.	Bolts.	Sundries.
1½ in. bt. and bk. flap. 1 pr. 2 „ — 3 pr. 2 in. butts. 2 pr. 2½ in. ditto. 1 pr. 1 „ 1 „ — 3 pr. 3 in. ditto. 1 pr. 3½ in. ditto. 1 pr. 1½ in. brass butts. 1 pr. 2 in. ditto. 2 pr. 1 „ — 3 pr. 4 in. ditto. 1 pr. 5 in. ditto. 1 pr.	Cupb. 1 1 — 2 Rimd., br. furn. 1 6 in. mort. china furn. 1 1 — 2 10 in. draw-back. 1 Patent latch. 1 Brass escutcheon. 2	Br. sash fastg. 1 1 1 — 3 Br. casement fastg. 2 3 ft. shutter-bar and plates. 1 Br. rack chain. 1 Br. knob turnbuckle. 1 1 1 — 3 Br. thumb-screw and plates. 1 Br. hook and eye. 2	10 in. br. barrel. 2 SCREWS. Handrl. scr. 3 Scr. bolt to newell. 2	Screw nut and joint to newell cap. 1 C. i. newell. 1 C. i. shelf-bracket. 2 Japd. clk. pins 6 China finger-plates. 2 pr. Ebony drawer knob. 4 Br. sk. fl. rings. 2 1 — 3 Br. hooks. 3 doz.

SEATS OF INDUSTRY.—XXVIII.

LIVERPOOL (*continued*).

BY WILLIAM WATT WEBSTER.

THE docks of Liverpool are the most extensive and convenient in the United Kingdom, and have been both an important cause and an important effect of its commercial prosperity. Mention has already been made of the first dock constructed at the port, in the beginning of the eighteenth century; but previous to that date efforts had been made to improve the navigation

of the Mersey, and the efficiency of the harbour of Liverpool. In 1694 Thomas Patten, of Warrington, widened the river, and made it navigable from Runcorn to Warrington. The old dock, which occupied an area of less than three and a-half acres, soon proved too small for the wants of the town, and was subsequently filled up; the new custom-house being built on its site.

In 1734 the Salthouse Dock was commenced, but it was only opened in 1753; and in 1761 an Act was obtained for building George's Dock, which was completed in 1771. Authority was obtained in 1784 for building two other docks, the King's and the Queen's; the former was opened in 1788, and the latter in 1796. The Prince's Dock, one of the largest on the Mersey, being 500 yards in length, and covering an area of nearly twelve acres, was completed in 1821. Since that date several enormous docks have been constructed; among others the Huskisson, which covers an area of 15 acres, 993 square yards; and the Brunswick, which has an area of above twelve acres; while the old docks have been improved and extended. Two new docks were finished in 1867. Liverpool now possesses about fifty docks and basins, extending along the margin of the river for about five miles; having nearly seventeen miles of quay space, and covering a total area of upwards of 700 acres, exclusive of the docks of Birkenhead on the opposite bank of the Mersey, which are four in number, including Wellesley Pool, which is considered the finest dock in the world. The docks of Liverpool were principally erected under the superintendence of Jesse Hartley, Esq., and are justly regarded as one of the great engineering triumphs of the century. Many of these docks are surrounded by spacious warehouses; those enclosing the Albert Dock, for instance, having cost £358,000, while the dock itself cost £141,000. An admirable feature of the Liverpool harbour consists in its two large floating landing-stages, one of which is 1,002 feet in length, 82 feet in width, and 4,500 tons in weight.

LIVERPOOL FROM THE MERSEY.

The completion of the Liverpool and Manchester Railway, which was opened in September, 1830, and cost £876,000—more than double the estimate laid before Parliament—marks an important stage in the progress of Liverpool. By an agreement entered into between the Bridgwater Canal Company and the Leeds and Liverpool Canal Company, the former acquired exclusive possession of the traffic between Liverpool and Manchester, although it was unable to forward the goods entrusted to it with the promptitude the trade required. Mr. Huskisson complained in the House of Commons that "cotton was sometimes detained a fortnight in Liverpool, while the Manchester manufacturers were obliged to suspend their labours; and goods manufactured at Manchester could not be transmitted in time, in consequence of the tardy conveyance." To remedy this grievance, an enterprising Liverpool merchant, named Mr. Sanders, in 1820 started a project for laying down a tramroad between the two towns, and he was soon joined by other merchants who were not interested in maintaining the monopoly of the canals. This scheme resulted in the Liverpool and Manchester Railway, which, however, had to contend against strong prejudice and powerful vested interests. Among the merchants who gave evidence before a Committee of the House of Commons in favour of the railway, in 1825, two deserve a place in this paper, because they exercised a potent influence on the trade and general well-being of Liverpool. One of these merchants was John Gladstone, the father of the present Prime Minister of England; and the other was William Brown, the founder of the Liverpool Free Library; of whom Cobden said in 1844, that he "held in his hands one-sixth part of the trade between this country and the United States." From the evidence of Mr. Gladstone we learn that

upwards of 10,000 vessels, with cargoes weighing in all 1,180,914 tons, entered the port of Liverpool in 1824; and that the dock dues, which amounted to £9,200 in 1787, when he settled in the town, had by 1824 increased to fifteen times that amount. The entire value of the goods received and shipped by Mr. Brown about this period amounted sometimes to £1,000,000 a year. There were then four lines of ships, sixteen in all, trading regularly between Liverpool and New York; and two lines, comprising eight ships, going to and from Philadelphia. The average value of the cargoes of these vessels was calculated at £50,000, but the goods they carried were in some instances worth three times that amount of money.

At the present time no less than four-fifths of the trade between the United States and Great Britain is carried on through Liverpool, as well as a large portion of the trade with South America and the West Indies; it also possesses a considerable share of the trade with the East Indies and China, although in the latter department Liverpool is surpassed by London. In 1864 the total number of vessels that entered the port amounted to 4,045, of which 2,898, with an aggregate of 1,372,203 tons burden, were British; and 1,147, representing a total burden of 498,292 tons, were foreign. From British colonies there arrived at the port in that year 1,127 British and 106 foreign vessels; while from foreign countries there came 1,771 British and 1,041 foreign vessels. The total value of the exports from Liverpool in 1864 was £72,748,031. In 1866 there belonged to the port 2,998 vessels, of which 2,569, of an aggregate burden of 1,326,317 tons, were sailing ships; and 429 were steamers, with an aggregate burden of 205,664 tons. The exports of the produce and manufactures of the United Kingdom from Liverpool, during that year, represented a total value of £87,486,497, against £41,449,797 from London; and 12,622 vessels, with an aggregate burden of 4,749,428 tons, entered the port. The importation of cattle and pigs into Great Britain from Ireland, which in 1866 amounted to upwards of £8,000,000, is carried on to a great extent through Liverpool.

For many years Liverpool has been the principal point of departure for emigrants from Great Britain and Ireland, and it is now the greatest port of emigration in the world. Large bodies of emigrants from Germany, and other parts of the Continent, find it cheaper to set sail from Liverpool for their various destinations, than from any port in their own countries. Steamers of large size, unrivalled speed, and with excellent accommodation for passengers, leave the harbour almost daily for New York, and other ports of the United States; and a magnificent fleet of steam-vessels, of unexampled magnitude, are engaged in trade with New York, Boston, Halifax, Rio de Janeiro, Buenos Ayres, Lima, Lisbon, Oporto, and the Mediterranean.

The manufactures of Liverpool consist chiefly of ship and boat building, cable and anchor casting; the construction of marine engines; and other branches of industry connected with the sea. Shipbuilding has declined during recent years, and Liverpool is now inferior in this respect to Sunderland, and to her great transatlantic rival, New York. The manufacture of soap is more extensively carried on in Liverpool than in any other town in the kingdom, and it is also one of the chief centres of the manufacture of chronometers, watches, and watch movements, of which latter large quantities are annually exported. In and near the town there are large distilleries of tar, turpentine, and whiskey; extensive rice and flour mills, saw mills, sugar refineries, cigar factories, roperies, and glass and alkali works.

Liverpool has nearly doubled its population every twenty years since the beginning of the present century. In 1861 its population numbered 443,938, and in 1871 it contained 493,346 inhabitants. Up to a recent date Liverpool consisted of narrow, irregular, ill-paved streets, lined with dull heavy-looking houses, and was regarded as one of the most unhealthy towns in England; but within the last forty or fifty years, and especially since the passing of the Local Sanitary Act of 1846, great improvements have been effected; and there are now few towns in Great Britain with wider, more handsome, and better-cleaned streets, and more substantial and sumptuous houses. In 1846 the water-supply, which before that date had been in the hands of private companies, who derived it from wells sunk into the red stone, was transferred to the Corporation at a cost of £554,807; and in the same year the latter obtained an Act authorising new works for the conveyance of water from a distance of twenty-six miles, which were opened in 1856, and cost £700,000. A new charter was granted to Liverpool by William III. in 1695, which was confirmed with a few emendations and additions by George II. and George III.; and by this charter the town was governed down to the passing of the Municipal Reform Act in 1835. By that measure the town was divided into sixteen wards, and placed under the government of a mayor, fifteen other aldermen, and forty-eight councillors. The parliamentary borough was enlarged by the Boundary Act, so as to include the out-townships of Everton, Kirkdale, West Derby, and Toxteth Park.

The principal public buildings in Liverpool are the Town Hall, St. George's Hall, the Exchange, and the Revenue Buildings. The Town Hall, founded in 1749, is an elegant Grecian structure; a handsome dome, supported by Corinthian pillars, and surrounded by an open gallery, rises from the centre of the building. The Exchange Buildings, which form three sides of the square enclosed by the Town Hall, were begun in 1803, and completed in 1809, at a cost of £110,840. In the centre of the square, a bronze statue of Nelson, designed by Wyatt, and executed by Sir R. Westmacott, was erected in 1813, at a cost of £9,000. The Revenue Buildings cover an area of 6,700 square yards, and comprise the office of the Inland Revenue, the office of the Commissioners of the Docks, and the Post Office. St. George's Hall is a sumptuous building in the Corinthian style; one portion of it is set aside for the Assize Courts, and the other for a concert-room, which is capable of accommodating an audience of 1,200.

There are about 150 churches and chapels in Liverpool; a third being connected with the Establishment, about 14 being Roman Catholic, 21 Presbyterian, 15 Independent, 16 Wesleyan, 2 Jewish, 1 German, and 1 Greek. Liverpool is provided with an unusual number of charitable and benevolent institutions, the most prominent being the Royal Infirmary, the Northern and Southern Hospitals, the Industrial Schools, and the Blue Coat Orphans' School. Among the principal educational, literary, and scientific institutions in the town, besides the Free Library and Museum, already incidentally mentioned, we may note the Botanic and Zoological Gardens, the Observatory, for which a new building was erected at Bidston in 1865, the Collegiate Institution, Queen's College, the Medical Institution, the Royal Institution, the Mechanics' Institution, the Society of the Fine Arts, the Academy of Fine Arts, the Egyptian Museum, and the Exchange, Lyceum, and Athenæum News-rooms and Libraries. Liverpool has several good theatres and concert-rooms, and in addition to the Botanic Gardens it has another fine park at Toxteth. Mrs. Hemans, William Roscoe, and Dr. Currie, the biographer of Burns, are among the most celebrated natives of the town.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXX.—TYCHO BRAHE.

BY JAMES GRANT.

THIS celebrated astronomer was born on the 14th of December, 1546, during the reign of Gustavus I. of Sweden, at Knudstrop, in the county of Schonen, near Helsingborg. When seven years old he was taught Latin; and for five years studied under private tutors. On the death of his father—an event which occurred when Tycho was very young—he was adopted by his uncle George Brahe, who, in 1559, sent him to study rhetoric at Copenhagen. The great eclipse of the sun, which occurred on the 21st of August in the following year, seems to have greatly impressed his mind, as it happened at the precise time astronomers had foretold it; hence, he began to consider astronomy as something divine, and purchasing the tables of Stadius, by studying them he rapidly gained some idea of the planetary system.

In 1562 young Brahe was sent by his uncle to Leipzig to study law, and there, by his acquirements, he manifested indications of wonderful talent. His natural inclinations, however, were not legal; he disliked the dry study of law, and preferred that of the heavenly bodies, and to the latter he applied himself so assiduously, that notwithstanding the injunctions of his uncle or the care of his tutor, to keep him close at the studies for which he had come to Leipzig, he attained a great knowledge of astro-

nomy. With what he could save from his pocket-money he purchased every book he could meet with on that subject, and read them with attention and enthusiasm, procuring ultimately, in cases that puzzled him, the assistance of his private tutor, Bartholomew Schultens. After a time, having procured a small celestial globe, he took opportunities, when Schultens was in bed, and when the weather was clear, to examine the constellations in the heavens, to learn their names from the globe, and their motions from observation.

Returning to Denmark in 1571, his studies and assiduity won him the favour of his maternal uncle, Steno Billes, who, being a lover of learning, gave him a convenient place at his castle of Herritzvad, near Knudstrop, for the erection of a building wherein to continue his observations and have a laboratory. Brahe built another observatory at Wandsbeck near Hamburg, when residing with the Count Rantzau. This edifice is still standing, and a bust of him is placed in one of the upper rooms. But it was at Knudstrop that, in 1572, he discovered a new star in the constellation Cassiopeia. Soon after this, having married a pretty peasant girl far beneath his rank, a quarrel ensued between him and his relations, and it was of a nature so violent that the king, then Frederick II., had to interpose his authority ere a reconciliation could be effected.

By command of the latter, in the following year he began to lecture at Copenhagen on the planetary system; and in 1575 he began his travels, and passing through Germany proceeded as far as Venice, where Luigi Mocenigo, under whom the famous battle of Lepanto was won, reigned as Doge.

Aware that he was coldly viewed by his relations in consequence of his marriage, he resolved to settle at Basle in Switzerland with his wife and children; but King Frederick, loth to lose a man so capable of doing honour alike to Denmark and to Sweden, promised, with a discriminating generosity that did him honour, to bestow upon him for life the island of Huen, in the Sound, between Copenhagen and Landscrona, and usually called by seamen, in those days, the Scarlet Isle. It was very fertile, and is seven miles in circumference. Frederick did more, for, however intolerant in religious matters, he was ever bountiful to the learned: he bestowed upon Tycho Brahe a pension of 2,000 crowns out of his treasury, a fee in Norway, and a canonry in the Cathedral of Roskilde which brought him a thousand more.

In the course of four years Brahe had built in the centre of his island the handsome castle of Uraniburg, which had many splendid apartments; and therein he had an observatory and all his books, mathematical and astronomical instruments. Adjoining it he erected a mill for making paper, a printing house, and laboratories for chemical investigations; but his favourite place for studying the stars was at Stellenburg, an edifice which he erected westward of the castle expressly for the purpose of an observatory. The rest of the isle he laid out in gardens, with fish-ponds, and in every way made it one of the most charming places in Denmark.

There Brahe resided for twenty years, pursuing his astronomical observations with remarkable industry. In these he was usually assisted by ten or twelve intelligent students, whom his generosity inspired him to provide for and keep about him, and whom he instructed in mathematics and astronomy.

In 1589 he received a visit from James VI. of Scotland, who was accompanied by his Lord Chancellor and many Scottish nobles. The king had recently been married at Upsala to the Princess Anne of Denmark, and though the limit of his stay in that country was to have been only twenty days, it extended to six months. James made Brahe many noble presents, and wrote some Latin verses in his praise; and the Scottish Chancellor (afterwards Lord Thirlstone), who had some pretensions to literature in his time, became intimate with him, and spent much of his time at Huen during the winter of 1589.

Brahe's tranquillity, his domestic happiness, and his studies, were all now fated to be destroyed. Soon after the death of his royal patron Frederick, he fell a victim to the envy and malignity of the ministry; they aspersed him to Christian IV., who in 1596 stripped him of his pension, his fee in Norway, and his canonry. He was then compelled to quit his favourite isle, which was bestowed upon a mistress of the king, and she, in a spirit of mere wantonness, is recorded to have destroyed all his works and buildings.

With his reduced household Brahe now took up his residence in Copenhagen, and with some of his instruments continued his astronomical observations and chemical experiments, until the same malevolence that drove him from Huen procured from Christian IV. an edict to discontinue even these.

Compelled now to leave Copenhagen, the unfortunate Brahe conceived the idea of seeking an introduction to Rodolph II., Emperor of Germany, who was fond of mathematics, mechanics, and chemical experiments—an amiable monarch, who, according to Voltaire, knew everything but the art of government. To pave the way for an interview, Brahe published his carefully-prepared "Astronomiæ instauratæ Mechanica," illustrated with plates, and dedicated it to the Emperor, who thereupon invited him to Prague. Thither Brahe repaired, and was received with the utmost honour by Rodolph, who assigned him a magnificent house, with a pension of 3,000 crowns, and the promise of a permanent fee for himself and his sons. With the latter and his students—among whom was the celebrated Kepler—he settled, in the latter end of 1598, in the Bohemian capital, where he built an observatory, the site of which is now occupied by the mansion of a noble family.

Tycho Brahe had the vulgar weakness, incident to his age, of giving credit to judicial astrology; but this superstition did not render him the less an astronomer, or the less able in mechanics. "His fate," says Voltaire, "was the same with other great men; he was persecuted in his own country after the death of the king his protector; but he found a noble patron in the Emperor Rodolph, who made him ample amends for all his losses, and for the injustice of courtiers."

The famous astronomical tables of Brahe and Kepler bear the emperor's name, being called the Rodolphine Tables, just as those which were made in Spain by two learned Arabs in the twelfth century bore the name of king Alphonso. Brahe did not long enjoy the new ease and affluence which surrounded him, as he died at Prague on the 4th of October, 1601, in his fifty-fifth year.

The apparatus of Brahe was purchased by the Emperor for 20,000 crowns; it remained, however, useless and concealed till the troubles of Bohemia ensued, when the army of the Elector Palatine plundered the city, and in a spirit of barbarism broke his instruments to pieces, and applied the brass and other metals to uses for which they never were designed. His great celestial globe of polished brass was, however, happily preserved and deposited with the Jesuits at Naysia in Silesia, from whence it was afterwards taken, in the year 1633, and placed in the hall of the Royal Academy at Copenhagen.

The family of the great astronomer is still in existence, and has been considered one of the oldest and noblest in Sweden. The present possessor of their great and antique château of Skugkloster, which was built in 1630 by Gustavus Wrangel, one of the most celebrated generals of the Thirty Years' War, is a lineal descendant of Tycho Brahe, and likewise of Count Brahe, who led the centre of the Swedish army at the battle of Lützen, in 1632. The château came to the Brahe family by marriage with that of Wrangel, and there is carefully preserved a portrait of the astronomer, and of the beautiful Ebba Brahe, to whom Gustavus Adolphus was so tenderly attached, and whom he would have made Queen of Sweden, but for the schemes of his mother, who married her by fraud or force to Count Jacques de la Gardie.

SHIP-BUILDING.—XIII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS (*continued*).

The plates forming the skin of an iron ship are secured to each other and to the frames by means of numerous closely-spaced rivets. These fastenings are made of superior qualities of iron, and are formed (as shown in Fig. 41) by means of rivet-making machines, some of which are most ingeniously constructed. The holes through which they pass are generally punched in the plates and frame angle-irons, and in the outer plates they are afterwards enlarged conically, or "countersunk," as shown in Figs. 39 and 40. The rivets are heated before being put in place, and when driven through from the inside a heavy hammer or "dolly" is held against the

head, while workmen outside beat down the point into the countersunk hole; to make good work, the rivet when cool should fill the hole. In cooling it is sure to contract somewhat, and a common rule for ensuring a good fit afterwards is to form the countersink as illustrated on the upper rivet in Fig. 39. The centre, A, of the hole on the inner surface of the plating is joined with the sides of the hole near the common surface, and these dotted lines produced form the sides of the countersink. This rule is, however, often departed from. When "knocked down," the point of the rivet is sometimes made slightly convex beyond the surface of the plate, as in Fig. 39; and in other cases is made flush, as in Fig. 40. Different builders have their own practice on such unimportant matters.

Punching the rivet-holes has been much objected to, on the ground that the plates are weakened thereby, and that it is difficult to ensure the exact correspondence of the holes in overlapping plates and frames. Efficiency in the fastenings obviously depends greatly upon such correspondence being obtained, so that the rivets may pass fairly through the holes; and with care it can be obtained, even when the holes are punched. The other objection to punching, its weakening effect, is not so easily removed, and it has led to the suggestion of drilling instead of punching. As the application of drilling machinery to iron ship-building has not yet been carried far, the much greater cheapness and rapidity of work rendered possible by punching has enabled that operation to keep its place. Should drilling machines be improved, however, so as to enable them to be used economically, it is probable that they will, to a great extent, displace punching, at least in the larger ship-yards; and if steel comes into general use this change is all the more likely to take place, as that material appears to suffer much more from punching than iron does. It is a good plan with steel, if the holes are punched, to anneal the plates afterwards, as the injury done by punching is then greatly lessened.

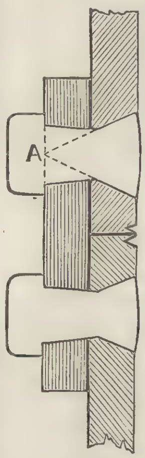


Fig. 39.

Punched holes are not exactly cylindrical like drilled holes, but are a little larger at the side which is most distant from the punch when it is made to press upon the plate, so that the holes are slightly conical, as shown in Figs. 39 and 40; and in making rivets a conical enlargement is formed under the heads to fit them (as in Fig. 41). On this account care ought always to be taken to punch the holes *from the faying surfaces* of plates; that is to say, from the outer surface of the laps of inside strakes, and the *inner* surface of the laps of outside strakes. When this precaution is taken, and the rivets are put in, their sections within the limits of the two plates resemble two truncated cones with a common smaller end. Hence, if by any corrosive action, or other cause, the rivet-heads should be worn away, the rivets would still hold the plates firmly together; whereas if the holes in the inner plates were punched from the inside surface, the rivets would have no holding power independently of the heads. There are many other matters of practical interest in connection with riveting, to which we hope to refer in another paper; but we must now proceed to describe the ordinary methods of arranging the fastenings in the edges and butts.

It may fairly be assumed that the in-and-out plan of plating need only be considered in this connection; and we shall then have to deal with lap-joints for the edges and with flush-joints at the butts. The edges are either "single" or "double" fastened. Single fastening is illustrated in Fig. 42, and is so simple as to require no explanation. Double fastening may be either "zigzag" as in Fig. 43, or "chain" as in Fig. 44. The latter arrangement is the more recent, and is now more frequently used, its chief advantages probably being the uniformity of spacing and the clearness from the butts which it permits in the edge-rivets. On the zigzag plan it will be noticed that a rivet comes directly in the butt, and that long spaces occur in one of the rows of rivets where the frames cross the plates; although this is sometimes obviated by placing two edge-rivets in each frame, it is more usual to follow the arrangement of Fig. 43. In the iron-clad ships of the navy, double chain riveting is always employed for the edges of the bottom plates. In merchant ships a similar plan is usually followed for at least the thicker plating; but when plates of $\frac{1}{2}$-inch or $\frac{3}{8}$-inch in thickness are employed, single-edge fastening is thought sufficient. And there can be little doubt that so far as the strength of the edge-connection alone is concerned, single riveting would answer every purpose; the use of a double row of rivets adding, of course, to the strength, but being rendered advantageous rather by its effectual "closing" of the lap-joint. Thick plates, being much less flexible than thinner plates, of course require more edge-fastening in order to secure the close contact so desirable in water-tight joints. This latter consideration practically regulates the spacing of the rivets in the edges, the "pitch" of which—or their distance from centre to centre—should lie between $3\frac{1}{2}$ and $4\frac{1}{2}$ times their diameter if the joint is to be made properly tight. The breadths of laps required are for single riveting from $3\frac{1}{4}$ to $3\frac{1}{2}$ diameters, and for double riveting from $5\frac{1}{2}$ to 6 diameters of the rivets. To caulk a lap-joint (such as in Fig. 40), it is first necessary to notch the edge of the plate with a suitable tool, and to drive the "burr" thus formed close against the inner plate. This simple operation is found to answer every requirement.

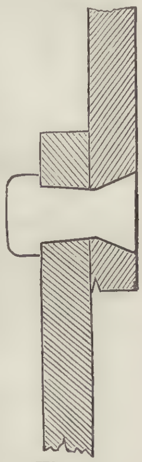


Fig. 40.

The plates are fastened to the frames by rivets spaced from 7 to 9 diameters apart from centre to centre, except in wake of transverse water-tight bulkheads, where the pitch is made about one-half as great, and other special methods are adopted, which will be explained hereafter. The edge-rivets in wake of the frames have to pass through three thicknesses, and more than usual care is required in order to secure good holes for them. On this account it is usual to leave the holes in the frames in way of the laps or "lands" of the plating, unpunched until the plates are fixed, and then to drill them, or else to "bore" them out with a sort of portable punching machine. All the other rivet-holes would be punched in the frame angle-irons before they are put in place, and they should be punched before the frame angle-irons are bent, in order to make thoroughly good work.

Turning now to the fastenings of the butts, we meet with much greater variety and difficulty. At present our remarks will be confined to a description of the principal plans that have been used, and in a future paper we shall attempt to show what are the true principles on which all arrangements of butt-fastenings should be based. Figs. 42—47 illustrate the chief methods adopted, and in each of them the vertical line drawn midway between the frames shows the butt of the plating, the boundaries of the internal butt-strap being shown in dotted lines. In each case also a sectional view is given showing the relative positions of the butted plates, the butt-strap, and the adjacent strakes of plating.

Fig. 42 shows a single-riveted butt of an outer or raised strake; the butt-strap proper being fitted between the edges of the adjacent sunk strakes, and two short supplementary straps, or fish-plates, being fitted over the joints of the strap and the sunk strakes. So far as the arrangement of the riveting is concerned, it will suffice to say that builders are scarcely ever content with single-butt fastenings, and that Lloyd's Rules only permit their use for the thin side plating of poops, forecastles, bulwarks, etc. Single riveting has, however, been used in very many cases, and Mr. Scott Russell has employed it in vessels built on the longitudinal system. It can only give sufficient strength against tensile strains, however, when associated with a good frame-space and a shift of butts giving a large number of passing strakes between consecutive butts; and even when this is the case a practical difficulty is raised on the ground that the butt is not efficiently closed and supported when single riveting only is employed. Respecting the other features of the plan, the use of fish-plates and a butt-strap, it must be stated that they were based upon the belief that it was necessary to strap the butt for the whole breadth of the strake, and that the fish-plates, besides doing this, helped to make the butt water-tight.


Fig. 41.

Another attempt in this direction is illustrated by the section

in Fig. 43, where the strap is actually forged in such a manner as to overlay the whole breadth of the butted plate. This was obviously a very expensive plan, and, as well as the preceding one, was not at all necessary, for every purpose is now found to be served by simply fitting the straps to the outside strakes between the edges of the inside or sunken strakes, as shown in the section in Fig. 44. With inside strakes it is, of course, easy to make the straps extend across the full breadth of the butted plates, and this is commonly done as shown in the sections of Figs. 45—47.

Reverting to Fig. 43, we have an example of a "double zigzag" butt-fastening, such as was formerly very generally employed, but has now given place, to a great extent, to "double chain" riveting like that shown in Fig. 44. Chain riveting is considered to be rather stronger than zigzag, and is now much from the butt. Sometimes, and more commonly, only the outer row of rivets on each side of the butt is thus treated. In either case the object of the plan is either to distribute the fastenings well, or to secure the butt with a greater number of rivets than could be worked in if double chain riveting were used. The spacing of the rows of rivets nearest the butt must, of course, be as close as before—*i.e.*, from $3\frac{1}{2}$ to $4\frac{1}{2}$ diameters—in order to allow of the butt being caulked.

The operation of caulking a butt-joint is illustrated in Fig. 39. Notches have to be cut with suitable tools in the abutting edges of each of the plates, and the burr so formed is carefully beaten into the joint to make it water-tight. Considerable advantages are gained by having the butts flush-jointed, both as regards the resistance offered to the ship's passage through the water, and the development of the strength of the plating. The

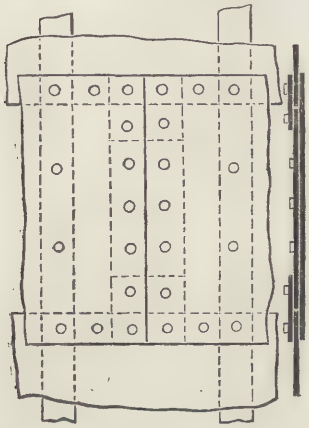


Fig. 42.

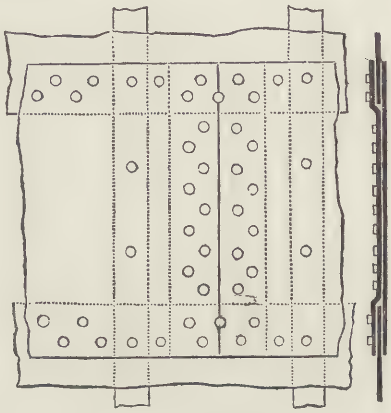


Fig. 43.

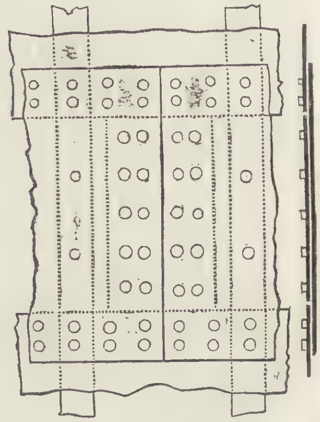


Fig. 44.

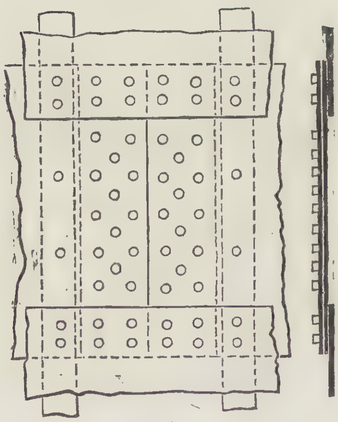


Fig. 45.

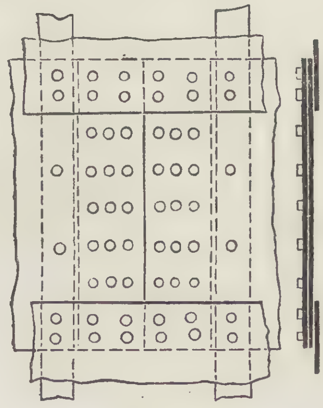


Fig. 46.

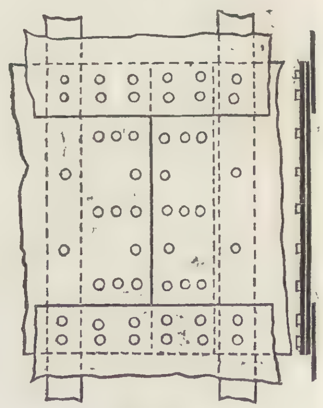


Fig. 47.

used in merchant ships, while it is exclusively employed in the ships of the Royal Navy. In fact, the general arrangement of fastenings in the bottom plating of the latter would be fairly illustrated by Fig. 44.

An example of a treble zigzag riveted butt is shown in Fig. 45, and one of treble chain riveting in Fig. 46. The former is but rarely used; and the latter, although it has been strongly advocated by some high authorities, has not been much employed. Sheer-strakes, middle-line keel-plates, and a few other longitudinal pieces, are almost the only cases in which treble chain riveting is adopted; but one or two builders have even gone so far as to use quadruple chain riveting in securing the butts of the sheer-strakes in vessels of unusual length. This seems quite unnecessary, however, and double chain riveting, associated with a good shift of butts, can be made to answer all essential requirements in fastening the butts of the outside plating. In Fig. 47 a plan not often used is illustrated, and will be seen to differ from that in Fig. 46, in having the alternate rivets left out in the two rows on each side most distant necessity for fitting the butt-joints closely was not formerly recognised by iron ship-builders, but now it is generally admitted; and either by planing or chipping the desired object is attained in well-built iron ships.

Butt-straps are usually of about the same thickness as the plates they connect, in some cases being $\frac{1}{16}$ of an inch thicker, in others $\frac{1}{16}$ thinner, and in others again of equal thickness with the plates. The fibre of the iron in the straps should always run in the same direction as that in the plates; so that the straps should be cut off the ends of plates. Their breadths vary with the character of the fastenings. For single riveting the total breadth of butt-strap would be from $6\frac{1}{2}$ to 7 times the diameter of the rivets, for double riveting from 11 to 12 times, and for treble riveting from 17 to 18 times. In both edge and butt fastenings it is a rule to have at least a space as great as the diameter of the rivets between the edge of the plate or strap and the row of holes nearest to it; and when there are two or more rows of rivets, the practice is to allow a distance varying from $1\frac{1}{4}$ to $1\frac{1}{2}$ times diameter between adjacent rows.

FISH CULTURE.—IX.

By Greville Fennell.

DISTINCTIVE CHARACTERISTICS OF SALMONIDÆ, ETC.

Yarrell tells us with truth that of the species of *Salmonidæ* existing in this country the characters and distinctions admit of considerable detail. Too much reliance has been placed upon colour, without resorting sufficiently to those external indications founded on organic structure which may with greater certainty be depended upon.

In the scale of the relative value of parts affording characters for distinction, the organs of digestion, respiration, and motion are admitted by systematic authors to hold high rank; and in the hope to induce sportsmen to become zoologists—so far, at least, as to enable them to determine the various species they may meet with by a reference to those external characters which are the most important—the specific distinctions in the genus *Salmo* will be illustrated by referring to the number and situation of the teeth, the form of the different parts of the gill-covers, and the size, form, and relative situation of the fins.

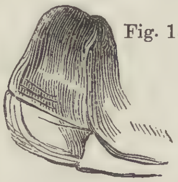


Fig. 18.

Fig. 16.

Fig. 17.

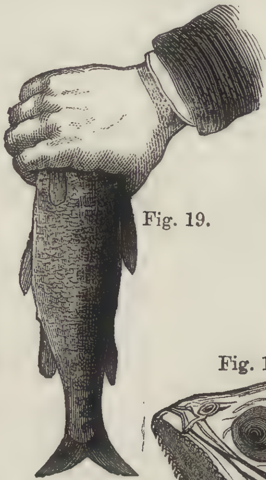
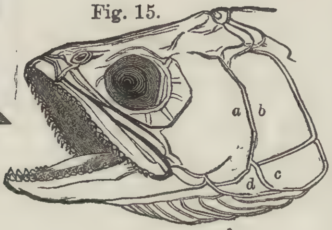


Fig. 19.

Fig. 14.

Figs. 14 and 15 here introduced represent a front view of the mouth and a side view of the head of the common trout. In the first of these illustrations (Fig. 14) *a* marks the situation of the rows of teeth that are fixed on the central bone of the roof of the mouth, called the vomer; *b*, *b* refer to the teeth on the right and left palatine bones, and the row of teeth outside each palatine bone on the upper jaw are those of the superior maxillary bones; *c* refers to the row of hooked teeth on each side of the tongue, outside of which are the lower jawbones. The trout is chosen, as showing the most complete series of teeth among the *Salmonidæ*; and the value of the arrangement, as instruments for seizure and prehension, arises from the interposition of the different rows, the four lines of teeth on the lower surface alternating, when the mouth is closed, with the five rows on the upper surface, those on the vomer shutting in between the two rows on the tongue, etc.

Fig. 15.



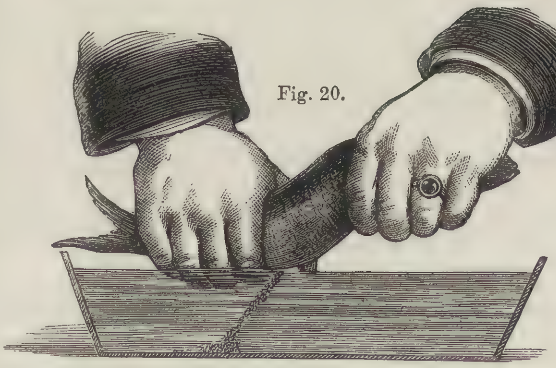


Fig. 20.

Fig. 15 represents, in outline, a side view of the head, of which *a* is the pre-operculum, *b* the operculum, *c* the sub-operculum, *d* the inter-operculum, *e* the branchiostegous rays; the four last parts together forming the movable gill-covers. The different fins are sufficiently indicated by being coupled, when referred to, with the name of the part of the body of the fish to which they are attached.

The external appearance of the adult salmon during the summer months, when it is caught in the estuaries of our large rivers, is too well known to require much description. The upper part of the head and back is dark bluish-black; the sides lighter; the belly silvery white; the dorsal, pectoral, and caudal fins dusky black; the ventral fin white on the outer side, tinged more or less with dusky on the inner surface; the anal fin white; the small soft fleshy fin on the back, without rays, called the adipose fat fin, or the second dorsal fin, is of the same colour nearly as the part of the back from which it emanates. There are mostly a few dark spots dispersed over that part of the body which is above the lateral line, and the females usually exhibit a greater number of these spots than the males.

These colours, differing but little, are, however, in a great degree common at the same period of the year to the three species that are the most numerous, as well as the most valuable, namely, the true salmon, the bull trout, and the sea or salmon trout, which are also further distinguished from the other species of the genus *Salmo* by their seasonal habit of moving from the pure fresh water to the brackish water, and thence to the sea, and back to the fresh water again at particular periods of the year. Further specific distinctions are therefore necessary, and those that will be pointed out as existing constantly in these species will, it is hoped, enable observers to identify not only each of these, but also the other species of the genus at any age or season.

The three illustrations on the left hand—viz., Figs. 16, 17, and 18—represent the form of the different parts of the gill-cover in the three species we have just named. Of these Fig. 16 is that of the salmon, Fig. 17 is the gill-cover of the bull trout, and Fig. 18 is the gill-cover of the sea or salmon trout. The differences are immediately apparent when thus brought into comparison.

In the salmon the posterior free edge of the gill-cover, as shown in Fig. 16, forms part of a circle; the lower margin of the sub-operculum is a line directed obliquely upwards and backwards; the line of the union of the sub-operculum with the operculum is also oblique, and parallel with the lower margin of the sub-operculum; the inter-operculum is narrow vertically, and its union with the operculum is considerably above the line of the junction between the sub-operculum and the operculum. The teeth of the salmon are short, stout, pointed and recurved. As stated in the generic characters, they occupy five situations at the top of the mouth—that is, a line of teeth on each side of the upper jaw, a line on each palatine bone, with a few only on the vomer between the palatine bone; the teeth on the vomer seldom exceeding two in number, sometimes only one, and that placed at the most anterior part. There are teeth extending along the vomer, as in the salmon trout, and more particularly so in some of those trout that do not migrate.

The inner surface of the pectoral fin is in part dusky; the tail being very much forked when young; but the central caudal rays growing up, the tail is much less forked the second year, and by the fourth year it has become nearly or quite square at the end.

It may be remarked here that, looking at the form of the three gill-covers, it will be obvious that a line drawn from the front teeth of the upper jaw to the longest backward projecting portion of the gill-cover in either species will occupy a different situation in respect to the eye; that the line will fall nearest the centre of the eye in the first, that of the salmon, and farther below it in the second, that of the bull trout.

The importance of these distinctions will be readily granted by the British reader, but far more so by the colonist, as it is now an ascertained fact that in Tasmania the flattering notion had long existed that salmon introduced from English ova were plentiful in their due season in the Derwent. This delusion has, however, recently been dispelled, the supposed salmon having been proved, after the above tests, to be trout, although trout of a very fine character. In order in future to obviate an error of this nature, Mr. Youell, to whom so much is due for the introduction of *Salmonidæ* in the Tasmanian river Derwent, and from thence to many other rivers, has caused casts to be made of the true salmon and trout, which, having been coloured from and to the life by the celebrated fish-painter, Mr. H. Leonidas Rolfe, have been forwarded to these colonies for general reference. Those, however, who would study similar casts, and much more of the greatest value, should pay a visit to the Fish Department of Mr. Frank Buckland at the Kensington Museum; and, if on a Saturday, that gentleman will cheerfully and lucidly explain a variety of circumstances in the history of fish culture which, if they do not induce the listener to follow out the pursuit in practice, will add no little to his wonder and admiration of the works of God.

Figs. 19 and 20 show the method of handling a trout of 1 to 3 lb. weight, and extracting the ova from a fish of from 3 to 5 lb. weight. We have already detailed the necessary process of manipulating a salmon of a much larger size.

We may observe that roach and dace are always heavier and fatter in those waters in which the well-known external parasite of the pike abounds. Upon one occasion our fisherman, Harry Christal, was fishing most fruitlessly for roach in the Colne at West Drayton, with the customary baits of gentles, worms, and paste, when by accident he impaled upon his hook one of these parasites, with which he was induced to fish, and caught in a short time three roach with that one specimen so accidentally captured. Hence the feasible suggestion that the entomologist and the botanist shall assist pisciculture by ascertaining the kinds of living creatures and plants on which fish thrive most, and by pointing out how they may be introduced into localities where naturally they are not found. The bottom of Loch Leven is in some places covered with a peculiar weed, sheltering various insects, chiefly crustaceæ, and small snails of various sorts; the lake also abounds in the more minute entomostracæ. Large quantities of both are found in the stomachs of the trout. This fact induced Mr. D. Esdaile ("The Rural Dean"), when consulted as to stocking a certain water with this prized trout, insisting upon the ova being accompanied by a quantity of the weeds and small stones to which the favourite food of the fish would adhere. In this respect Mr. Esdaile exhibited a proper discretion; not so another would-be benefactor to a stream in Hampshire, who brought up at some expense many bushels of the small snail of the lakes, which, while they lasted, fed the fish, but which themselves had not a chance of propagation for the want of the plant upon which they fed and propagated.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXI.—MATTHEW BOULTON, F.R.S.

BY JAMES GRANT.

Matthew Boulton, whose happy improvements in mechanics rendered many important services to his country, and whose name is intimately connected with that of James Watt and the progress of the steam-engine, was the son of Matthew Boulton, by Christian, daughter of Mr. Peers, of Chester, and was born at Birmingham on the 3rd of September, 1728. He was principally educated at the private grammar school of the Rev. Mr. Ansted, who officiated at St. John's Chapel, Deritend, and was taught drawing by Worledge, and mathematics by Cooper. When he attained manhood, we are told that "he was above the middle stature and well built; he was exceedingly disposed to encourage modest merit, and was fascinating in his manner and conversation."

In his native town, Birmingham—then consisting of little more than thirty streets, though celebrated for the manufacture of leather seven hundred years ago, and for that of coarse iron articles previous to the Revolution—he established himself as a manufacturer, and invented and brought to great perfection, about the year 1745, inlaid steel buckles, buttons, watch-chains, etc. Of these great quantities were exported to France, where they were purchased "with avidity by the English, as the offspring of *French ingenuity*."

His manufactory at Birmingham soon became inadequate to his extensive improvements and many experiments; and in the year 1762 he took a lease of Soho, near Handsworth, in the county of Stafford. Two miles distant from the city, it was at that time a barren heath, with a little eminence on the bleak summit of which stood one solitary hut, the abode of a warrener. By the year 1765, Mr. Boulton had converted this place into the site of his superb manufactory, at the expense of £9,000; and in the year 1794 he purchased the fee-simple of Soho, and much of the adjacent land.

Inspired by patriotic ambition and a desire to encourage home art and manufacture, he established at Soho a seminary for draughtsmen and modellers, seeking men who were talented, and whom he rewarded liberally. This soon led to his establishing successfully an extensive manufactory for ornaments in what is called *ormolu;* and these ornaments not only found their way into the royal apartments at Windsor and St. James's, but to those of all persons of rank and taste in most parts of Europe.

On discovering that the mill which he had erected fell infinitely short, as a force, even with the aid of several horses, of that which he required to complete the great works he had in view, he had recourse in 1767 to the steam-engine, which was yet in its infancy, and did not at first answer the expectations that had been formed of it; and yet, if we are to believe Dr. Darwin and Aikin, the idea of such a power is much older than the days of the Marquis of Worcester or of James Watt, as the former asserts that Hiero of Alexandria, who flourished a hundred years *before Christ*, had "an application of the force of steam to produce a rotative motion by the reaction of steam issuing from a sphere mounted upon an axis, through two small tubes, bent into tangents, and issuing from the opposite sides of the equatorial diameter of the sphere—the sphere being supplied with steam by a pipe communicating with a pan of boiling water, and entering at one of its poles;" while the latter in the first volume of his *Athenæum*, under the title of "Omnia," asserts that Pope Sylvester II. had clocks and organs which were worked by steam about the end of the tenth century; and M. Delescluze about thirty years ago made a discovery among the MSS. of Leonardo da Vinci, that carries a knowledge of the steam-engine back to the fifteenth century, in the design for a *steam-gun* called an architonnerre, or "an invention of Archimedes."

In 1769 James Watt, of Glasgow, as related in his memoir, had obtained a patent for improvements in the steam-engine, which induced Mr. Boulton to invite him to Soho, and also to settle there, to which he consented. In 1775 Parliament granted a prolongation of the patent for twenty-five years to the Messrs. Boulton and Watt, who, on becoming partners, established at Soho an extensive manufactory for these engines, from whence they were sent to the greatest mines, manufactories, and other works in England; and among the various applications of steam, that for coining was of considerable importance, as one engine, managed by a few boys of from twelve to fourteen years, worked a number of coining machines with greater success and exactness, than could be done by the same number of able-bodied artizans, without endangering their fingers, as the machine itself laid the blanks upon the die, perfectly concentral with it, and when struck displaced one pair to replace it by another. The coining mill, which was constructed in 1788, was greatly improved, and by the end of the century was adapted to work eight machines, each of which was capable of striking from 60 to 100 coins, of the guinea size, per minute, or equal to between 30,000 and 40,000 per hour. If such a coining mill had been erected in the Royal Mint, says Shaw in

his "History of Staffordshire," it would in cases of emergency be able to coin all the bullion in the Bank of England, without the necessity, which then existed, of putting Spanish dollars and other foreign coin in circulation. At the Soho mill, the same blow which struck the face and reverse, also formed the edge, whether milled, plain, or with an inscription, as in the case of crown-pieces.

"The whole of this magnificent and expensive apparatus (says Dr. Darwin) moves with such superior excellence and cheapness of workmanship, as well as with works of such powerful machinery, as must totally prevent clandestine imitations, and in consequence (as coiners were then hanged) save many lives from the hand of the executioner. If a civic crown was given in Rome for preserving the life of one citizen, Mr. Boulton should be crowned with a garland of oak."

In 1773 the ingenious method of copying pictures in oil-colours by a mechanical process had been invented at the Soho works, under the patronage of the proprietors; and, like oleography, was brought to such perfection as to make its productions be taken in some instances for the originals. The art was brought to perfection under the management of Mr. F. Eginton, who was also celebrated as a painter on glass; as stated in our paper on James Watt (Vol. II., page 139), the art of sun-painting by daguerreotype was not unknown to Messrs. Boulton and Watt.

The former, in 1788, struck with the coining machine a gold piece of the old guinea size, as a pattern, the letters of which were indented instead of being in relief, while the head and other devices were protected from wear by a flat border; and from the perfect rotundity of form, etc., with the aid of a steel gauge, it could with ease and certainty, by its specific gravity, be distinguished from any base metal. And previous to Messrs. Boulton and Watt's engagement to supply Government with copper coins, in order to bring their apparatus to greater perfection, they had exercised it in coining silver for Sierra Leone and the African Company, and copper for Bermuda and the East India Company.

Many of the beautiful medals presented, about that time, to distinguished officers in both services, were from time to time struck at the Soho works.

On the accession of the Russian Emperor Paul I., Mr. Boulton presented him with some of the most interesting articles of their manufacture, and in return, received—from that unfortunate monarch, who perished by violence—a letter of thanks and approbation, together with a splendid collection of medals, specimens of all the modern money of Russia, and of many minerals from Siberia. Among the medals was a massive golden one, bearing the head of Paul. This piece, the beauty of which is said to have been unrivalled, was struck from a die engraved for the then Empress, who from her youth had taken a great delight in the arts, particularly that of engraving on steel.

With a view to still further improving and facilitating the construction of steam-engines, Boulton and Watt, in conjunction with their sons, established a foundry at Smethwick, a village in Staffordshire, three miles from Birmingham, and intersected by the canal. There the powerful agent, which had already done so much, was employed to reproduce and multiply itself; and the engines, which were there fabricated with wonderful regularity, neatness, and expedition, were forwarded to all parts of the kingdom by the Birmingham Canal, which, by means of a wet dock, communicated with the foundry.

Thus, in a national point of view, the undertakings of Matthew Boulton were in an eminent degree highly valuable and important. By collecting around him draughtsmen and artists of various descriptions, rival talents were stimulated or called into existence, and successive competition multiplied to an extent greatly beneficial to the public; while that which before had been a barren heath was covered with objects of industry, with population and plenty. The Soho works alone covered many acres, and by the time the patent expired, and Watt withdrew from them, with an ample fortune, they afforded employment for more than 6,000 persons.

Prior to this the firm had become involved in a quarrel with the famous inventor of the patent lock, Joseph Bramah, whose irritation broke out fiercely in the evidence given by him in the case of Boulton and Watt *versus* Hornblower and Maberly, which was tried in December, 1796; and on being silenced by the judge, Bramah revenged himself in a pamphlet entitled "A Letter to the Right Hon. Sir James Eyre, Lord Chief Justice of the Common Pleas," etc.

In 1809 the apparatus for *first* supplying the city of Glasgow with gas—then a wonder of the age—was prepared by Boulton and Watt, and fitted at Anderston, a suburb one mile distant from the city cross; and the whole, we are told in a print of the time, "constitutes a very pleasing exhibition. Two iron retorts of a semi-cylindrical form, each capable of containing one cwt. of coal, yield at every charge 750 cubic feet of gas, which, after being washed so as to deprive it of any disagreeable smell, is conducted into a large cubical plate-iron gasometer, of a capacity equal to 1,120 feet. The gas evolved by the regular process of carbonisation, during the day, is herein stored up for use. From this magazine, which floats in a water cistern, a main-pipe issues, which afterwards branches into innumerable ramifications, some of them extending several hundred feet under ground; thence to emerge, diffusing over a multitude of apartments a kind of artificial day, so vivid is the illumination. The flame, however, though exceedingly bright, is very soft and steady, and free from that dazzling glare which has been so greatly complained of in the otherwise beautiful light of the argand lamps." Such was the simple account of this new mode of illumination, which brought the peasantry in from the Campsie Hills and the Renfrew villages, to throng the streets, and gaze at as a new marvel, and which even Sir Walter Scott had ridiculed as a wild idea of lighting cities with smoke!

"No trouble attends this beautiful illumination," adds the memoir read before the Philosophical Society of Glasgow in 1810; "the occasional attendance of one man in the gas-house to charge the retorts and mend the fire being all that is necessary; *and no trimming or snuffing are required.*"

No expense had been spared to render his own works handsome and uniform in architecture, as well as neat and commodious; and the taste with which Mr. Boulton adorned the gardens and laid out the pleasure-grounds, rendered his residence at Soho both pleasant and picturesque; and there he died in the year 1809. He was not only a member of the Royal Societies of London and Edinburgh, but likewise of that which bears the title of the Free and Economical at St. Petersburg, and of many other foreign scientific institutions.

"To comment upon the private character of a gentleman in Mr. Boulton's situation (says the *Scots Magazine*, for the year subsequent to his death) would be a useless task: we shall therefore only observe that, as his great and expanded mind formed and brought to perfection the wonderful works he produced, so he felt no greater felicity than that of diffusing happiness around him. For a long time previous to his decease he had been confined to his room by illness, and his dissolution daily expected. His memory will ever remain dear to the British nation, whose glory was advanced in proportion to his own fame. While we commemorate those great men who have sought their country's honour in the fields of war, we ought not to omit paying a just tribute to those who have promoted arts, industry, and commerce, and diffused plenty and comfort throughout the realm, by cultivating science and applying it to the arts of peace."

Playfair, in speaking of Mr. Boulton, describes him as "a man of address, delighting in society, active, and mixing with people of all ranks with great freedom and without ceremony." James Watt also spoke of his partner in the highest terms, ascribing to his friendly encouragement, his partiality for scientific improvements, and his ready application of them to the purposes of art, his intimate knowledge of business and manufactures, his extended views and liberal spirit, most of the success that attended his own exertions.

THE LATHE.—IX.

By Henry Northcott.

SLIDE-REST APPLIED TO SIMPLE LATHE—SMALL FOOT-LATHE.

Fig. 28 shows the application of another form of the slide-rest to a simple lathe. This slide-rest has a surface-slide next the lathe-bed, and the slide and centre line of bed are kept at right angles, so that with the driving head-stock in its usual position, the motion of the surface-slide will always tend to produce a plane surface upon the face-plate of the lathe.

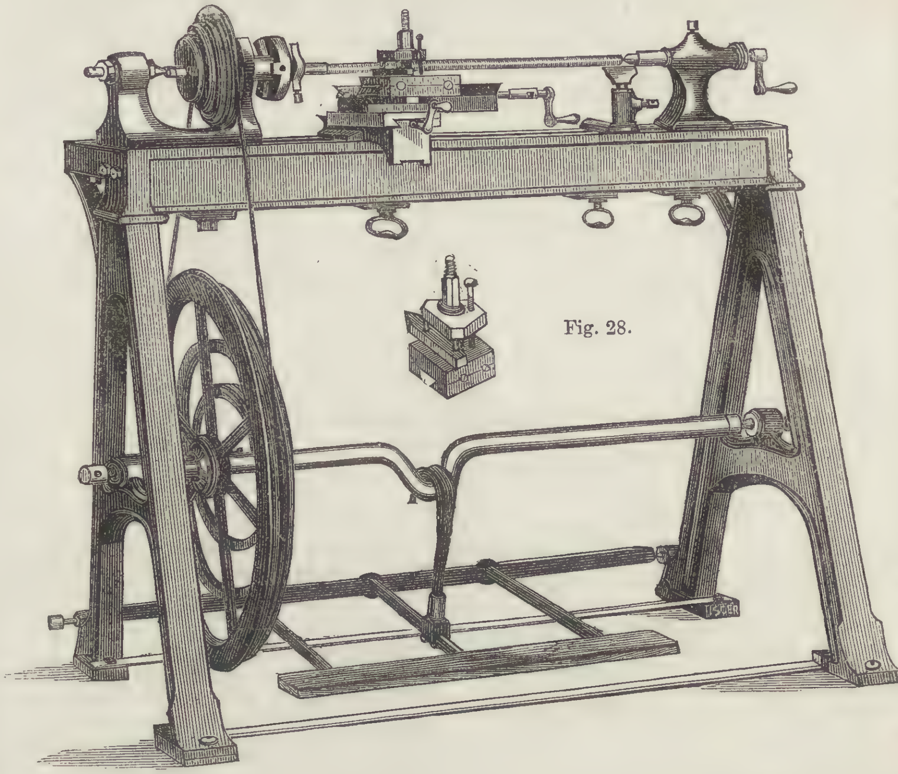


Fig. 28.

The traverse-slide is placed upon the surface-slide with the usual angular motion between the two. The traverse-slide, it will be observed, has a long motion, and this is a very desirable feature in all slide-rests applied to hand-lathes, as a good length of cut can be taken with one setting of the slide-rest; whereas if the slide be short, as is too generally the case, it becomes necessary, when turning up a long shaft, to frequently move the slide-rest along the lathe-bed into a new position. In slide-lathes or lathes in which the rest itself is moved along the lathe-bed to form the traverse-slide, it is quite unnecessary to have a long traverse-slide upon the rest; and, indeed, a long slide would be rather an incumbrance than otherwise. It must not be forgotten, in constructing or choosing a slide-rest, that the longer a slide projects out over the supporting-slide or lathe-bed, the stiffer and stronger it must be to resist a given depth of cut. The present example errs probably on the safe side in respect of weight of metal, but it is better to have too much metal in a slide than too little. A slide-rest, and, indeed, the whole of a lathe, has not only to be strong enough to resist fracture from the strains to which they are subjected, but every part ought to be strong enough to withstand these strains without springing or yielding in the slightest degree. This necessitates a great deal of metal, and unless the designer be very careful in placing it by correctly proportioning every part, lathes and most machine tools are caused to look unnecessarily heavy and clumsy. If the tool, from any cause, does not keep firmly in contact with its cut, the effect is most unsatisfactory and annoying. A most disagreeable noise is generally produced, and the surface of the work is found to be very rough and uneven. But want of metal is not the only cause of unsteadiness in a slide-rest. No quantity of iron will produce a good slide-rest unless the fit of the various sliding parts be everywhere close, and the workmanship of every part accurate. A great deal also depends upon the position of the tool with respect to the rest and to its cut, and as much upon the shape and condition of the cutting-edge of the tool, especially if the slide-rest be rather weak or unsteady. A good tool-holder also, as before mentioned, is very necessary; and, in the rest at Fig. 28 the holder is of this quality. It is of the triangular plate variety, as in a previous example, but the working out is much more mechanical. There is the central bolt which is very strong, and is furnished wit

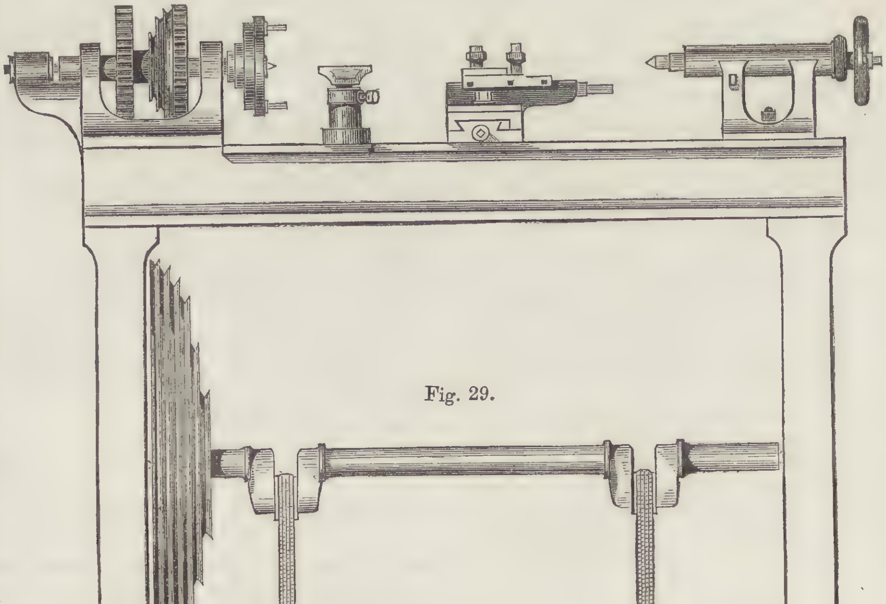


Fig. 29.

a well-fitting screw-nut. The length of the nut is unusually great as compared with the diameter, as the threads are subjected to a considerable amount of pressure and wear. The triangular plate has only one other screw through it, and this acts as a support to the third angle of the plate, and is adjustable to different thicknesses of tool, as in the previous example. At the two other corners of the plate are two knobs or projections made of hard steel, whose function it is to bear upon the tool which is placed underneath them. The two points are tightened down upon the tool by turning the nut upon the central spindle, and the tool is by this means firmly and securely held to its cut in any required position upon the tool-plate, as the triangular plate may be shifted anywhere around the central bolt. Altogether, this may be considered a fair specimen of the slide-

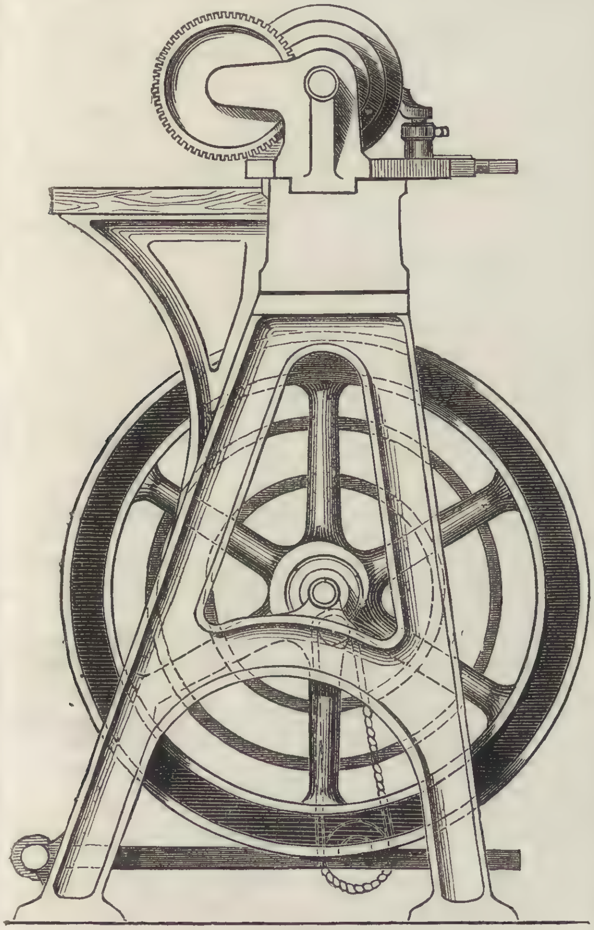


Fig. 30.

rest as usually applied to a hand-lathe. The illustration was engraved from a photograph taken from a lathe made by Mr. Munro, of Lambeth.

Fig. 29 is a front elevation, and Fig. 30 an end elevation of a small foot-lathe for hand-turning, but with slide-rest attached, as made by Sir Joseph Whitworth and Co., of Manchester. The lathe is driven by a treadle through two cranks, and the treadle and cranks are connected by two chains instead of the usual links. The chains pass over the crank-pins and around pulleys attached to the treadle-lever, as will be seen by the illustrations. The chains have a slow rolling movement when the treadle is in motion, and the friction is somewhat lessened by their use. Sometimes leather belts are used instead of chains; the former give perhaps a little more elasticity and a somewhat pleasanter motion when treading, but it would be difficult to say that one mode of connection has any substantial advantage over the other.

The crank-shaft is hung between centres, and the grooved cone-pulley has a set of four grooves for the fast speed and two slow-speed grooves in addition. The cone-pulley is made very heavy, so as to act as a fly-wheel, and carry the crank around against a heavy cut. The double gearing is of the usual kind, in which the wheels are slid into and out of contact with each other. The end pressure caused by screwing up the centres against work between them, and in other ways, is taken by a back-centre shown at the extreme left hand of the head-stock, and this, when practicable, is no doubt the best arrangement, as the thrust is direct, and the back-centre is easily adjusted to take off any pressure from the bearing-collars. In some cases, such as when change-wheels have to be placed upon the end of the lathe-spindle, the position of this back support becomes somewhat inconvenient, and it is sometimes expedient to receive the end thrust or back pressure upon the collars of the spindle-bearing. But in these cases the friction is certainly greater than when a proper back-centre is employed, as in the present example.

The spindle-nose carries a double or Clement's driver, and this looks rather heavy for the lathe-spindle. It may be questioned whether an ordinary driving-plate with a single arm would not do quite as well as the one shown in place, besides being considerably lighter. Both the hand tool-rest and the slide-rest are shown in position on the lathe-bed. The former is of the usual variety, as will be seen from the illustration. The slide-rest is an excellent one, and it would be difficult to find any fault either with its arrangement, proportions, or workmanship. The drawings will sufficiently explain its construction.

The screw head-stock has the internal screw and socket, the action of which has been already shown, and a sectional drawing of it given.

A bracket projects from each of the standards carrying the lathe-bed, and upon the two is placed a wooden shelf, which is very convenient for receiving the various tools, etc., that happen to be in use, and keeping them within easy reach of the operator.

Altogether, this lathe is an excellent example of a light hand-tool lathe, and the slide-rest is especially good; and in bringing our description of it to a close, it is needless to say that the workmanship of every part is first-rate.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIII.

BY E. WYNDHAM TARN, M.A.

PLASTERING.

The work of the plasterer belongs both to the outside and the inside of buildings. When any part of the outside of a building is covered with a coating of cement or stucco, this is executed by the plasterer. The internal work of the plasterer consists in covering the walls, ceilings, and partitions with a facing of plaster, adding ornaments, mouldings, cornices, etc., as may be required. Plaster or cement floors are also executed by this workman, and also the pugging on the sound-boarding which the carpenter has laid between the joists. White-washing or lime colouring to ceilings or walls belongs also to this trade.

For outside work or stucco there are a variety of different materials used, as well as modes of applying them. Rough casting, which is plaster sprinkled over with lime and small stones; rendering with blue lias lime mixed with sand; rendering with Roman or Portland cement, either neat or gauged with sand, plain or jointed to imitate stone. In measuring cement work, take all the surface that is coated with stucco in superficial feet, bringing into yards in the abstract; deduct all openings, state how many coats are used, and the proportion of sand to cement. Facias, pilasters, reveals, etc., are taken by the foot superficial; all mouldings are taken the girt by the running length, and the area in superficial feet entered in the bill. Arris edges, beads, quirks, $4\frac{1}{2}$ in. reveals, etc., are taken by the foot-run. All mitres, blocks, brackets, consoles, pateras, ornaments, etc., are numbered. Dubbing-out with tiles, in order to get an extra thickness or projection, is measured by the foot superficial, unless for a narrow string-course, when it is taken

by the run. The colouring of cement work, if not done with oil paint, is taken with the plasterer's work, by the superficial yard.

Stucco upon walls that are circular on plan is measured one and a-half times the girt by the height, and the area added to the plain work.

Panelled work is usually measured by taking the round of the panel as square arris, or moulding, describing the girt of the moulding.

No allowance is made for the scaffolding used in executing the stucco to outside walls of new buildings; but if it is done to old walls the scaffolding must be charged, when erected for the purpose of doing the work. In rendering old walls, the joints are raked out, and the walls axed, which is stated in the measurement, the work being taken as before by the superficial yard.

Cement floors are measured by the superficial yard, describing the proportions of sand and cement; but small works, such as hearths, coating cisterns, etc., are taken by the foot superficial.

In measuring the internal plastering to walls, take the round of the room by the height from floor to ceiling, if there are neither skirting grounds nor cornice, but if both, then by the height from the top of the grounds to half way up the cornice; this will be brought into superficial yards and described, rendering one coat, render and set if two coats, render float and set if three coats. Take the run of quirks to beaded angle-staffs. If, however, any part of the walls of the room is formed by a quarter partition, it must be measured separately from the brick or stone walls, and taken as lath and plaster—one, two, or three coats, as the case may be; and the same is the case if the walls are battened out for the plastering.

The ceilings are measured the length by the width from wall to wall if there is no cornice, and brought into superficial yards, as lath render one, two, or three coats. When there is a cornice, deduct its width once in each dimension, or take the area half-way across the cornice. Take the girt of the cornice by the length, and bring into superficial feet; number the mitres, ornaments, pateras, centre flowers, etc.; take the run of all continuous enrichments, and describe their girt. For very lofty rooms an extra price is charged for the use of scaffolding.

Friezes, soffits, raised or sunk panels are taken by the foot superficial, running the moulding or arris of the panels, and numbering the mitres.

Coves to cornices are measured separately from the moulding, the length by the girt, and brought into superficial feet.

Various cements are used for the internal finishings, the walls being either first rendered with common plaster, or with a rough coating of cement and sand, before the finishing coat is given. The measuring is similar to that above given for ordinary plaster, the quality of the cement work and number of coats being described. Skirting in cement, arrises, quirks to staff angle-beads, narrow mouldings, beads, enrichments, etc., are taken by the foot-run. Work in panels, pilasters, shafts, friezes, mouldings, cornices, etc., is measured by the foot superficial.

In measuring the plastering to walls that are circular on plan, take the height by one and a-half times the girt, and bring into superficial measurement, adding it to the straight work.

Whitening or colouring plasterer's work is measured by the superficial yard, describing the number of coats, and what tints are to be used. If cornices have to be in more than one tint they are taken separately, and also all enrichments that are picked out in colour. Old work, that has to be re-whitened or coloured, is described as wash, stop, claircolle, and whiten or colour, by the superficial yard.

Pugging, which is composed of coarse stuff and chopped hay, laid upon the sound-boarding between the joists of a floor, is measured by the square of 100 superficial feet, taken over the whole floor, without deducting the thickness of the timbers.

In entering plasterer's work in the dimension book, the surveyor uses various abbreviations. Thus, "R." stands for render; "R. S.," for render set; "R. F. S.," for render, float, and set; "L. P.," for lath and plaster; "L. P. S.," for lath, plaster, and set; "L. P. F. S.," for lath, plaster, float, and set; "W. S. C. W.," for wash, stop, claircolle, and whiten; "L. W.," for lime whiten; and so forth.

We shall now give a specimen of the entries of plasterer's work in the dimension book, which may serve to illustrate the foregoing rules:—

EXTERNALLY—PORTLAND CEMENT.

	25 6		Plain face on brick, Pd. cement with 3 parts washed sand, jointed.
	22 0	561 0	
4)	6 6		Deduct.
	3 0	78 0	
		483 0	
2)	10 3		Pilasters, ditto, ditto.
	1 4	27 4	
2)	22 0	44 0	Arris edges, ditto.
4)	16 6	66 0	4½ in. reveals, ditto.
4)	17 6	70 0	Architrave moulding, 3 in. girt, ditto.
	25 6		Dubbing-out with plain tiles.
	1 6	38 3	
	25 6	25 6	Chamfered edge.
	25 6		Moulded string.
	1 3	31 11	
2)	2 0		Ditto caps and bases.
	1 6	6 0	
		37 11	

No. 4 mitres to mouldg., 15 in. girt. 10 brackets, 12″ × 6″.
„ 8 mitres to mouldg., 3 in. girt.

	22 0		R. and rough cast on brick.
	18 0	396 0	

INTERNALLY.

2)	15 0		Pugging of coarse stuff and chopped hay, 1½ in. thick.
	12 6	375 0	
8)	4 0		R. with Portd. cement and 3 of sand to hearths.
	1 6	48 0	
	15 0		Ditto, ditto, to floors.
	10 6	157 6	
		205 6	
	52 0	52 0	Square skirtg. 7 in. wide, in Pd. cement.

PLASTERING.

	56 6		R. and S. to brick wall.
	10 0	565 0	
	10 0		Add.
	1 6	15 0	
		580 0	
3)	6 6		Ddct.
	3 6	68 3	
		511 9	
	15 0		L. P. and S. to ceiling.
	12 6	187 6	
	21 0		Ditto soffit of stairs.
	3 0	63 0	
		250 6	

	21 0	21 0	Quirk.
	56 6 10 0	565 0	R. F. and S. on brick.
	10 0 1 6	15 0	Add.
		580 0	
3)	6 6 3 6	68 3	Ddct.
		511 9	
4)	10 6	42 0	Quirk.
2)	15 0 12 6	375 0	L. P. F. and S. to ceiling.
	24 0 3 0	72 0	Add soffit of stairs.
		447 0	
	24 0	24 0	Quirk.
2)	54 0 1 6	162. 0	Cornice.
	54 0	54 0	Enrichment, 6 in. w.

No. 12 mitres to 18 in. cornice.
,, 2 centre flowers, 3 ft. diamr.

3)	15 0 12 6	562 6	S. C. and W. to ceilings.
	45 0 3 0	135 0	Add soffit of stairs.
		697 6	
	54 0 1 6	81 0	S. C. and distemper 2 tints to cornice.

PARIAN CEMENT.

	56 6 10 0	565 0	Trowelled for painting.
	10 0 1 6	15 0	Add.
		580 0	
3)	6 6 3 6	68 3	Ddct.
		511 9	
4)	10 6	42 0	Quirk.
	45 0	45 0	Skirting 9 in. high, moldg. 3 in. gt.

No. 6 mitres to skirting.

2)	7 0 1 6	21 0	Pilasters.
	2 0 1 6	6 0	Plain moldg.

We have now given a specimen of entries of plasterer's work in the dimension book, first taking all parts which are to be worked in Portland cement, externally and internally; then the plasterings applied to the walls, ceilings, etc.; and, lastly, the finer work that is done in Parian cement. We have now to prepare an abstract of these dimensions, which will be found below. In this the work in cement and the work in plaster are taken separately. In the former the work in Portland cement with the addition of three parts sand is distinguished from the work in Parian cement, and is taken according to the mode of measurement by superficial area, run, or number. The work in the finer cement is also taken in the same way, but in this case it has been found more convenient to arrange the different kinds of measurement under one another instead of side by side. This has also been done with the rough casting and pugging, which is taken by superficial measurement. The same course is also adopted in dealing with the plastering, which is also arranged according to superficial area, run, and number.

ABSTRACT.

Portland Cement, with Three Parts Sand.			Parian Cement.	Plastering.			
Superf.	Run.	Number.	Superf.	Superficial.		Run.	Number.
R. on bk. jointed. ft. 9)483 0 53 yds. 6 ft. Pilasters. ft. 27 4 Moldd. ft. 37 11 Hearths and floors. ft. 205 6 Dubbing out with plain tiles. ft. 38 3	Arris edge. ft. 44 0 $4\frac{1}{2}$ in. reveals. ft. 66 0 3 in. moldg. ft. 70 0 Chamfd. edge. ft. 25 6 7 in. skirting. ft. 52 0	Mitre to 15 in. mo. 4 Ditto 3 in. ditto. 8 Brackets, 12″ × 6″ 10 R. Rough cast. ft. 9)396 0 44 yds. Pugg. $1\frac{1}{2}$ in. thk. ft. 100)375 $3\frac{3}{4}$ sqrs.	Trowelld. for paintg. ft. 9)511 9 57 yds. Pilaster. ft. 21 0 Moldg. ft. 6 0 Run. Quirk. ft. 42 0 Skirtg. 9in. high, with 3 in. mo. ft. 45 0 Number. Mitre to skirtg. 6	R. S. ft. 9)511 9 57 yds. R. F. S. ft. 9)511 9 57 yds. S. C. W. ft. 9)697 6 $77\frac{1}{2}$ yds. S. C. Distr. 2tints to cornice. ft. 81 0	L. P. S. ft. 9)250 6 $27\frac{3}{4}$ yds. L. P. F. S. ft. 9)447 0 $49\frac{3}{4}$ yds. Cornice. ft. 162 0	Quirk. ft. 21 0 42 0 24 0 87 0 Enrichment, 6 in. w. ft. 54 0	Mitre to 18 in. cornice. 12 Centre flower, 3 ft. diam. 2

PRINCIPLES OF DESIGN.—XXX.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

STAINED GLASS.

FROM early times it has been customary to colour glass. To the ancient Egyptians a method of forming glass of various tints was known, and by producing a mass of glass consisting of variously coloured pieces vitreously united, and cutting this into slices, they, in a costly and laborious manner, produced a sort of stained glass which might have been employed for the sides of lanterns or other purposes. The Greeks were acquainted with a similar process, and bowls formed in this manner by them are common in our museums.

Soon after the re-discovery of glass in our own country, methods of colouring it were sought out, and beautiful cathedral windows were formed, which, soon after the discovery of the art of producing coloured windows, were of such beauty, and were so thoroughly fitted to answer the end of their creation, that little or no improvement upon these early works has even yet been made, and much of the decorative glass which we now produce is far inferior to these early works both as regards design, colour, and mode of treatment.

A window must fulfil two purposes—it must keep out rain, wind, and cold, and must admit light; having fulfilled these ends, it may be beautiful.

If a window commands a lovely view let it, if possible, be formed of but few sheets (if not very large, of one sheet) of plate glass; for the works of God are more worthy of contemplation, with their ever-changing beauty, than the works of man; but if the window commands only a mass of bricks and mortar inartistically arranged, let it, if possible, be formed of coloured glass having beauty of design manifested by the arrangement of its parts. A window should never appear as a picture with parts treated in light and shade. The foreshortening of the parts, and all perspective treatments, are best avoided. I do not say that the human figure, the lower animals and plants, must not be delineated upon window glass, for, on the contrary, they may be so treated as not only to be beautiful, but also to be a consistent decoration of glass; but this I do say, that many stained windows are utterly spoiled through the window being treated as a picture, and not as a protection from the weather and as a source of light.

Fig. 143.—DESIGN FOR A WINDOW IN STAINED GLASS.

If pictorially treated subjects are employed upon window glass, they should be treated very simply, and drawn in bold outline without shading, and the parts should be separated from each other by varying their colours. Thus, the flesh of a figure may be formed of glass having a pink tone; the robe of glass which is green, purple, or any other colour; the flower of white glass; the leaves of green glass; and the sky background of blue glass. All the parts will thus be distinguished from each other by colour, and the distinction of part from part will be further enhanced by the strong black outline which bounds the parts and furnishes the drawing of the picture.

Strong colours should rarely be used in windows, as they retard the admission of light. Light is essential to our well-being; our health of body depends in a large measure upon the amount of light which falls upon the skin. Those wonderful chemical changes, in the absence of which there can be no life, in part, at least, depend upon the exposure of our bodies to light; let our windows, then, admit these life-giving rays. It must also be remembered that if light is not freely admitted to an apartment the colours of all the objects which it contains, and of its own decorations if it has any, are sacrificed, for in the absence of light there is no colour.

It is not necessary, in order to the production of a beautiful window, that much strong colour be used; tints of creamy yellow, pale amber, light tints of tertiary blue, blue-grey, olive, russet, and other sombre or delicate hues, if enlivened with small portions of ruby or other full colours, produce the most charming effects, and by their use we have consistent windows.

A good domestic window is often produced by armorial bearings in colour being placed on geometrically arranged tesseræ of slightly tinted glass. In some cases such an arrangement as this is highly desirable, for the room may thus get the benefit which a bit of colour will sometimes afford, and at the same

time a pleasant view may be had through the uncoloured portion of the window. As an illustration of this class of window, we extract one from the catalogue of those excellent artists in stained glass, Messrs. Heaton, Butler, and Bayne, of Garrick Street (Fig. 145)

No architectural constructive feature should be introduced into a window—thus, an elaborate architectural canopy overshadowing a figure is not at all desirable. If a figure is formed of a perishable material, and stands on the outside of a building, it is well that it be protected from the rain by a canopy; but such a contrivance when introduced over a figure drawn on a flat window is absurd, being useless. Let us always consider what we have to do before we commence the formation of any ornamental article, and then seek to do it in the most simple, consistent, and beautiful manner.

More than once in the course of these papers I have protested in strong terms against pretence in art and art-decoration—the desire to make things appear to be made of better material or more costly substances than what they have in reality been wrought from; that leads most men to paint and varnish a plain free-stone mantelpiece in imitation of some expensive marble, or to make doors and window-shutters, skirting and panelling that the carpenter has fashioned out of red or yellow deal, assume the appearance of oak, or maple, or satinwood, by the deceptive skill of the grainer. In no case can the imitation ever approach a fair resemblance to the reality it is proposed to imitate. The coarse, rough grain of the soft free-stone, which is incapable of receiving a polish, or rather of being polished until it becomes as smooth, and even, and lustrous as good glass, can never be made by successive coatings of paint and varnish to afford a satisfactory resemblance to the marble that it is supposed to represent, however carefully the cunning hand of the painter may have imitated the veins, and spots, and curious diversities of colour with which Nature has variegated the surface of the substance that he is endeavouring to copy. Nor, again, can a coarse-grained, soft wood, however skilled may be the hand that manipulates it, be treated so as to resemble the texture and smoothness of hard, close-grained wood, which from its very nature is capable of receiving the high polish that the softer material can never take if treated by the same process. And what is applicable to the treatment of wood and stone is applicable also to the treatment of glass: for as a free-stone mantelpiece or deal door, however suitable and pleasing to the eye either may be when simply painted in the one case and varnished in the other to preserve the surface from the deteriorating influences of dirt of any kind, can never be made by the exercise of the highest skill to present the appearance of marble or oak; so glass, by the application of colour rendered transparent by varnish, can never be brought to resemble glass stained or painted by the legitimate method, either in delicacy of tint, or depth, and richness, and brilliancy of deeper colour. The greater part of the imitative stained glass, or "diaphanie," as it is styled, fails not only in colour, but in design; and in this indeed it may perhaps be said to be chiefly faulty. The designs for the most part which are printed on paper in colours err principally in being too elaborate, and in representing figures and scenery which are not in character or keeping with the designs that are usually represented in painted glass. If confined to simple diaper work, or borderings and heraldic emblems, as shown in Figs. 144 and 145, or patterns similar to that shown in Fig. 143, the artistic effect produced would be more satisfactory, although it can never equal genuine stained glass in depth of colour or purity of tone. But there is no necessity for any one who is averse to doing so to resort to imitation even in a means of decoration apparently so far beyond the reach of most of us as painted glass. The material, in the first place, is cheap, and the mode of procedure has been described in some of the papers that appear in this work under the general title of "Practical Application of the Fine Arts." It may be urged by many that a want of skill or an inability to draw may present an obstacle to success. It may do so for a time; but a will to succeed at last, aided by patience and perseverance, will ultimately overcome all obstacles.

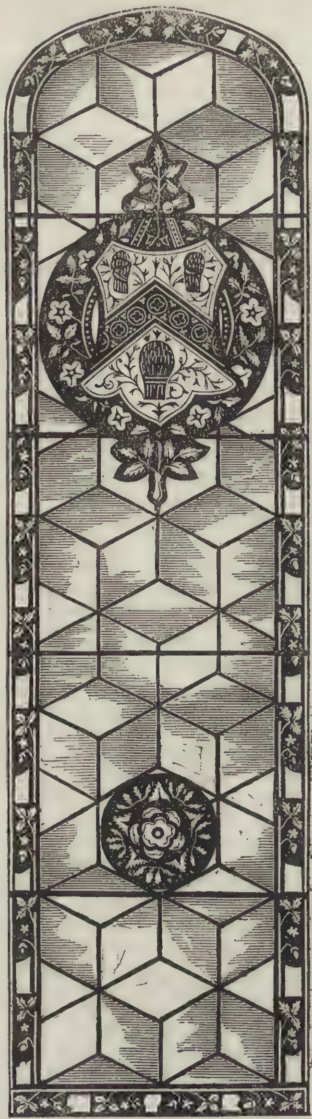


Fig. 145.—WINDOW WITH SHIELD, ETC.

Fig. 144.—WINDOW-BORDER IN STAINED GLASS.

SOLDIERING.—V.

BY A STAFF OFFICER.

ARMAMENT: CAVALRY.

WHILST immense improvements have been gradually introduced into the equipment of other arms of the service, hardly anything has occurred to render the action of cavalry on a battle-field more effective than it was formerly. Now, as formerly, the power of cavalry in actual attack depends on the extent to which the velocity and weight of the horse is brought into play. It follows at once that the weapons which are most suitable in attack, are those which give fullest effect to these. Little improvement has been introduced into the hand-to-hand weapons of war—the sword and the lance. On the other hand, since men on horseback can only use fire-arms with less, not with more efficiency than men on foot, improvements in them tend scarcely to increase the power of cavalry.

The result, however, is not to render the action of cavalry less important, but to change its character. There are still cases, as the fight at Rezonville in the last war has taught us, in which even now vast masses of cavalry may, by devoted courage, so hamper and delay the action of an enemy as to save an army. But the cavalry is almost inevitably destroyed. A general has still sometimes to call upon his horsemen to make the sacrifice, but it is like asking men to lead a forlorn hope. Victory may result. Few of those who have prepared for it will live to see it. The great problem, however, under ordinary circumstances, is how to get with the least sacrifice the greatest amount of value out of an arm which a very brief consideration of the facts will show to be even more essential than formerly to the safety and success of an army.

The tremendous power of modern weapons has rendered the element of *time* one of even more absolutely vital consequence than it was formerly. For within a given time, a properly prepared army may inflict upon an army unprepared a disaster far more complete and final than was ever possible formerly. Hence to obtain the fullest information at the earliest possible moment has become not merely an *important* matter, but one of altogether paramount importance. Now time is the very element in which cavalry has always had the advantage over all other arms of the service.

Nor is that all. The suddenness of the effects of modern fire-arms has produced a tendency to as sudden discouragement even among the best of troops. Gravelotte supplies us with a notable instance of it, even among those who had been victorious in every fight. Such panics, if troops are fit to fight under modern conditions at all, pass away almost as rapidly as they occur. If an enemy observe them, and taking advantage of the favourable moment act upon it, victory is in his hands; if he allows the chance once to pass away, his hope of its returning is small. Now, here again time being the element of all importance, cavalry is the arm to be used. Moreover, the effect of cavalry has always been essentially moral. Nothing impresses the imagination so much as the apparent power of clouds of horsemen pouring down upon the seemingly devoted heads of the pigmy-looking foot-soldiers who are crouching in the ground to take aim at them. It needs only that the infantry man now-a-days should be calm, and should realise the efficiency of his weapon, in order to render the attack, powerful as it is in appearance, impotent in practice. But men in panic are not calm, do not reason. Hence cavalry thrown at the right moment upon discouraged and somewhat disordered infantry, ought to render it impossible for them again to take part in the action then going on.

Furthermore, since an army once beaten is greatly discouraged, great opportunities are sure to present themselves after a battle, and towards its close. What I spoke of in the last paragraph are rather incidents in the course of an action. Whole armies are rarely so disorganised at once by a single panic, that they may be freely assailed in the way there spoken of whilst a battle is in full vigour. A brigade or a battalion, under exceptionably severe stress of fighting, exposes itself to such assaults, it may be at a very early stage of the fight. These incidents, whenever they occur, must be taken advantage of. But after a lost battle, or towards the end of the day when it is becoming clear that the battle will be lost, the whole of the beaten army, without being panic-struck, tends to yield to a sense of despondency. Troops that have been comparatively little engaged feel this almost as much as those that have been hotly pressed, provided the fresher troops have been able to realise the extent of the disaster, and unless they are exceptionally war-tried men. Here again, therefore, immense opportunities, now as formerly, present themselves to the arm which strikes most rapidly, and which most impresses the imagination. The effect produced by cavalry acting in this way is in reality *far greater* than formerly; for while men cowed by disaster are not much more deadly enemies if they have breech-loaders in their hands than if they had the Brown Besses of the Peninsula, let them once recover themselves, and each man represents a far greater power to be overcome than in the old time. It is, therefore, more important than ever to strike whilst the task is relatively easy. On the other hand, a much smaller body of infantry, if it retain order and remain uncowed by disaster, will now be able to repel the incursions of pursuing cavalry.

Once more, since cavalry will be used on both sides, and when one body of horsemen is thrown in to take advantage of panic or disorder, another will be launched to save the assailed infantry from disaster, it becomes of the utmost importance to have in hand a body of horsemen so armed and equipped as to be able to overcome any whom the enemy may bring into the field.

I have pointed out as I proceeded through the above enumeration of the chief purposes for which cavalry is required, how far the conditions apply at the present moment; but the distinctions between the different classes of cavalry to meet these necessities have sprung up in the past, and have in the main differed little, except perhaps in the relative degrees of their importance, from those which we now possess, or indeed now require.

The first broad distinction in the classes of cavalry employed is that between "heavy" and "light:" the former, intended to consist of such powerful men and horses, that it shall be able to ride down all opposition, and to be so equipped as to be victorious in onsets of cavalry against cavalry; the latter, intended to develop to the full all qualities of rapidity and prompt action. We have also what are known as "medium" cavalry, intended to do much the same work as the light, but to be also a supporting body for them in the shock of battle.

The light cavalry is especially designed to fulfil all those duties of gathering information, watching round the outskirts of an army, foraging, striking short rapid blows against disorganised troops, to which I have already alluded as of so much importance, and which were popularly attributed to the Prussian Uhlans or lancers during the recent campaign. In Prussia, however, the Uhlans are medium, not light cavalry, and for many of the duties of this kind they are the least fitted of all, except the very heavy cavalry. During the late war it became important to throw as large bodies of cavalry as could be gathered together round the advancing armies, and hence as in open country lancers were very effective, and little actual fighting was required, they, as well as others, were pushed forward far in advance of the army. The lance has been rightly called the queen of cavalry weapons, for it is the one which gives to the horseman the fullest play in those respects in which he has advantage over the man on foot. Its effect is produced by the actual forward dash of horse and horseman; the very nature of the blow which it delivers protects its holder. For the horseman, even the sword is most effective when it is used as a rapier, not when it is raised to strike a blow. For the rapier thrust gains force from the horse's impulsion; the sword cut gains nothing from that cause, and in the delivery lays open the swordsman: hence the advantage of a weapon which, depending solely on its thrust, has for it the longest possible reach. The lance is, however, far more valuable for large bodies of horsemen acting together, than for mere scattered advanced parties; it is awkward and fatiguing for very light work. For these purposes the hussar is the prince of horsemen. The armament of hussars with us is the sword and breech-loading carbine, with no defensive armour. The lancer has sword and pistol besides his lance, with no defensive armour.

But whether for outpost duty—that is, for the watch and ward over an army, and collecting information—or for the battle-field, light cavalry of whatever kind require to be supported. Experience in the past has been fully corroborated by recent evi-

dence, as to the fact that the support which they require is of two distinct kinds. For battle fighting, where cavalry attack will be met by cavalry counter-attack, the best of all support is that furnished by powerful cuirassed regiments, equipped with armour genuinely defensive against cavalry weapons, who by sheer weight and impetus, as has been proved again and again, can, if properly handled, be almost certain to ride down the best of light horsemen. The light horsemen may catch them at a fault; but when the two fairly meet, the lightly equipped soldier specially prepared for other work has hardly a chance against his powerful and well-protected enemy. On the other hand, these cuirassed regiments require to be kept in reserve specially for these duties; to employ them in the harrying light work of a campaign is to destroy them. For this purpose another kind of support requires to be furnished. The name " dragoon " has become a most indefinite one with us, implying little else than a heavy cavalry soldier. In its origin, in its earlier use, as understood by Napoleon and during the American War of Independence, it had a very different meaning. The latest experience of the war of 1870 convinced all who passed through it that the old dragoon must be revived. His essential character was that of a mounted rifleman: his pride to be so effective on foot that the enemy were certain to mistake him for the best of infantry soldiers, and to believe that the solid infantry of the army, and therefore the guns were arriving, so that it was time to abandon any weakly held outpost. Rossel has recorded how often villages which otherwise would have been hotly contested for hours, have fallen at once before such trained dragoons, because of the false impression they created that greater force was at hand. But to gain this the dragoon must be in all respects equipped and trained as an infantry soldier; taught to ride well, only that his transference from point to point may be as rapid as possible. His drill must be identical not with that of cavalry but with that of infantry when he is on foot; every part of his equipment must tend to make him put confidence not in the force of his horse in a charge, but in the efficiency of his weapon when he is dismounted: such ought to be the real characteristics of this most invaluable of soldiers. We do not at present, except in the Hampshire Yeomanry, possess a specimen of him; his creation has been invariably advised by all who have considered the question how to bring the gain of time which the horse offers into such combination with our all-efficient fire-arms as shall enable us to seize positions by virtue of the horse's rapidity, and to hold them by virtue of the power of the new arms. The difficulty that has always stood in the way is the dread lest we should only create bad infantry and bad cavalry: we are sure to produce that result as long as the only test we apply as to efficiency is that of parade. Dragoons will constantly tend more and more to be mere heavy cavalry; but in proportion as our training in peace time becomes more and more a study of analogous duties in war, in that proportion will an appreciation of the importance of the mounted rifleman or dragoon be extended. Men will take a pride in belonging to a body which has more opportunities for dealing startling blows that tell throughout a whole campaign than, in proportion to numbers, any other part of an army whatever. During the fighting in the Le Mans campaign the Prussian cavalry, to save the weary infantry, took duty all round the resting army. Many were the fights which occurred in that enclosed England-like country between the Prussian dismounted horsemen and the French levies; the result was that before long all became convinced that as such duties must often now fall to the lot of cavalry, it was essential to place in their hands a good far-reaching fire-arm. Hitherto the Prussians had had a most legitimate fear lest if the fire-arm were made too good, the cavalry should begin to trust to it when mounted rather than to the impulse of the charge. The result would inevitably be that the horseman, using his fire-arm under circumstances of less advantage than the foot-soldier, would be beaten in every encounter. But the days are past when we could afford to deprive ourselves of an important advantage, lest our men should make a wrong use of it. We must meet the difficulty by superior training, not by defective armament. This, however, we shall have to consider later. At present it is sufficient once more to press the fact that whatever fire-arms may be given to cavalry, they are essentially either for use on foot, in exceptional instances for cavalry encounters, or for isolated foraging. For the assault of broken infantry and all such purposes the less they are used the better. The only distinction in our service among the heavy cavalry is, that the household cavalry are armed with cuirass, steel helmet, sword, pistol, and breech-loading carbines. The " Heavies " are armed with brass helmets, swords, and breech-loading carbines. The Scots Greys alone are equipped so as to look like mounted guardsmen. It may be safely predicted that one of the earliest results of the first war we are engaged in will be the creation of a corps of mounted riflemen. Unfortunately, creations of corps during war time are not easy now-a-days.

EQUIPMENT: CLOTHING.

We pass now to the consideration of those other matters of equipment scarcely less necessary to be noted even than armament itself. First of all, clothing; and, secondly, the few essentials which require to be carried on the persons of the foot-soldiers, and on the horses and carriages of the cavalry and artillery.

As to clothing: some means of distinguishing between the civil population and those engaged in fighting was felt to be needed as soon as war began to be conducted in a civilised manner. The importance, for the sake of the civil populations themselves, of insisting that none shall fight who do not wear the uniform of one of the armies engaged, has been pointed out again and again by those historians who have most carefully examined the question. Nevertheless, it almost always happens that during a period of war patriotic and personal excitement drives the peasantry of an invaded country into acts of individual hostility against the enemy. The duty of the government of a country so invaded is to publish at once the clearest possible information to the people of the invaded districts, telling them by what sacrifices they can best aid the general effort to repel the invaders. The aid which true patriotism would offer is an entire submission to directions so issued. The great difficulty usually lies in this, that the mass of a large population does not realise what an invasion is till the hostile armies have shown themselves and committed acts asserting the right of the strong. Then furious wrath produces terrible acts, followed by more terrible reprisals. Hard as it may seem, it has been powerfully argued that the wisest and most humane course, where a whole population has not been able to fly before an enemy, and where the war is one between civilised nations, is to leave none but women and children, the aged and infirm, in the villages through which the invasion passes, and to sweep the whole virile population of those provinces into the service of the army. The population thus left should offer no resistance whatever to the enemy. No modern general dares to allow atrocities to be committed where no resistance has been offered. His difficulties will be too seriously increased by any such conduct. But what is for him an inconvenience, is for the peasantry decimation, if not destruction; for, preach as we may, no army will allow itself to be quietly murdered off one by one by men whom it has had in its power, and has spared on the understanding that as they do not wear the uniform which proclaims their hostility they will not act overtly against it.

The Prussians, economical as they are, meet the difficulty by having *his suit of uniform ready*, and his appointed place assigned to almost every man in the whole country who is capable of actively aiding their own army in any capacity. It is no doubt not necessary for us to take the precautions which are indispensable to nations unprotected by our strip of blue water, but the illustration is sufficient to show how very important a national question uniform may become. To the army it is the outward sign of its unity and of its common duty. If, therefore, the proposition from which I have started is true—that the question to be considered in each matter is how the spirit you desire can best be developed—it is scarcely possible to doubt that men should be taught to have a great respect for their uniform.

As all things which are necessary and good in themselves have a disagreeable part, so this is apt to present itself often to outsiders under a very unpleasing aspect. Foolish men in every profession and calling do not see the difference between a happy confidence that the work they have chosen is for them the best of all work, and a contempt for the work on which others are engaged. Foolish men outside every profession and calling mistake the pride which the best men will always have in their own business for personal egotism

and conceit. The two react much on one another, and hence it very often happens that it is regarded as a special offence of the army against the nation, that men are taught to hold up their heads proudly, and to walk along "as if everything they saw belonged to them." It is a misfortune that such mistakes as to the meaning of pride in a calling should be made on both sides. It is, no doubt, a misfortune that we are not in the millennium; when we are, it may be presumed that armies will cease to exist. But in the meantime, those who wish to have an army effective must be content to endure the sight of a certain amount of so-called "military swagger." If it is not accompanied by a certain special readiness to assist others, and to fit into awkward positions, it may be safely assumed that the man is the worse soldier on that account. To take a single instance, try whether those Life-Guardsmen who in front of the Horse-Guards offices seem to be each taking up the space of three men as they pace up and down, are when you speak to them more or less ready than the clerks in the War Office to lend you all the assistance in their power for getting the information you require.

It immediately follows from this principle of cultivating as far as possible the soldier's respect for his uniform, that his dress should be such as will tend to make him take a pride in it. A man dressed in sackloth and ashes may feel that his dress is exactly the one that he ought to wear, but it would be a contradiction in terms to say that he would take a pride in it; his object is to learn to take pride in nothing. I have often heard men say that you ought to make soldiers' clothing handsome, because handsome uniform is the bait with which to catch recruits. I do not think that is either a true or an honest way of looking at the matter. If it were a deceptive bait, I should say you did yourself more harm than good, since it is more essential to an army than to any other body to be joined by those only who heartily wish to belong to it. Moreover, as a matter of fact, those regiments which find it easiest to get good recruits, though they are largely assisted by their uniform in doing so, are certainly not those which are most gaudily dressed. The Rifle Brigade, for instance, is perhaps the most serviceably dressed of line regiments, but it is not the most showily got up. What I believe the fact to be is, that there is a certain contagiousness in any genuine feeling of pride in a good regiment; that that contagiousness is the best possible agency for recruiting; that the pride itself is to some extent fostered by a liking for their own uniform among the men of a corps, affected no doubt partly by what their civilian friends think of it.

The other matters which concern the clothing of soldiers are chiefly such as common sense would suggest; that it shall be judiciously modified according to the climate in which it is to be used; that it shall be as convenient and as durable as it can be made. There is only one point in which the conditions of a soldier's work introduce a matter of special importance; he should be able to carry certain changes of clothing with him if possible, and hence it is very advisable that his garments should be as light as other conditions will permit. Practically this is a matter so difficult to reconcile with cheapness and other requisites that it may be said to be wholly ignored.

OPTICAL INSTRUMENTS.—XXI.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

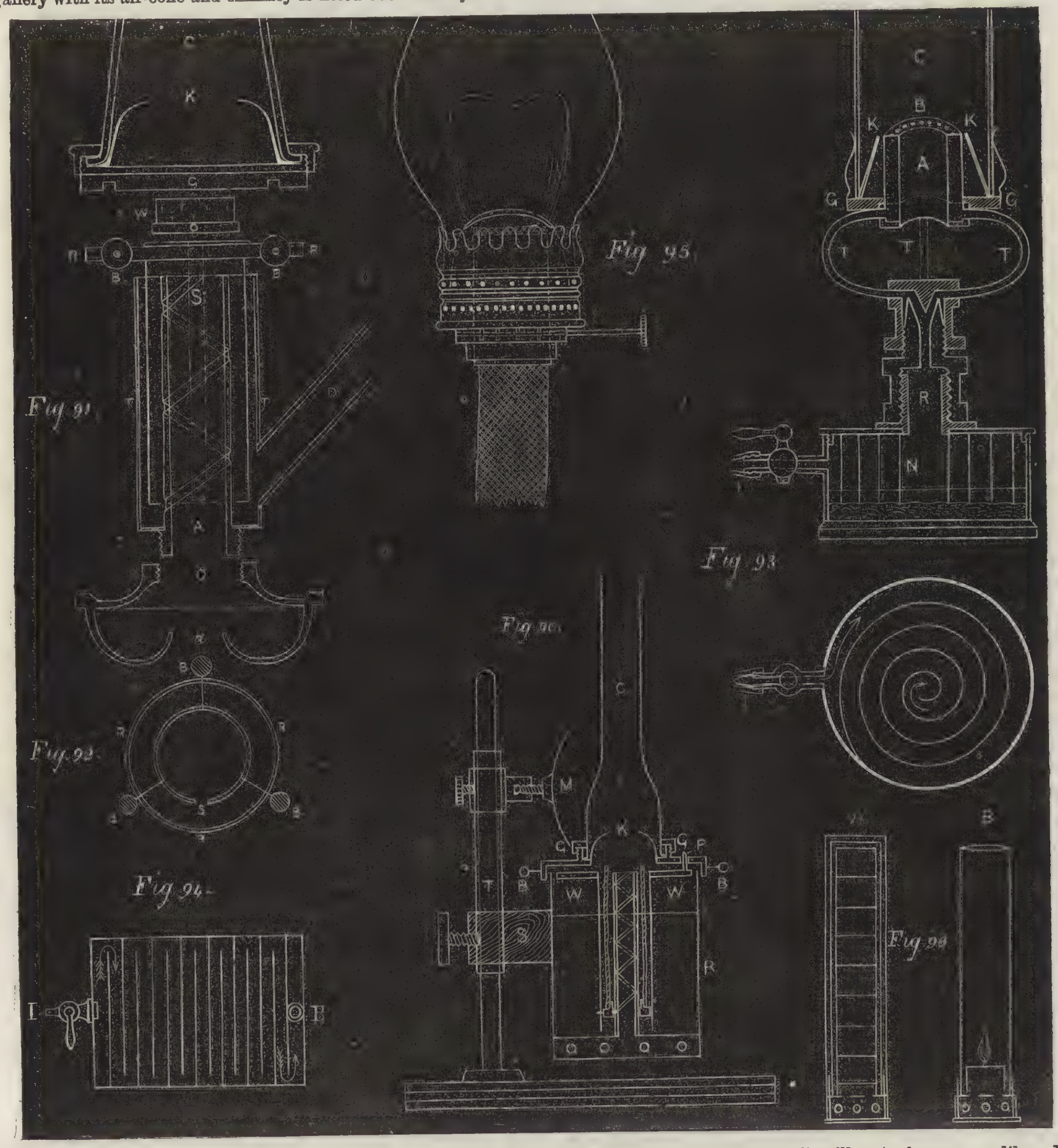
Paraffine Wax Burner.—Solid paraffine, together with the recently introduced "ozokerit," is extensively used for the manufacture of candles. For such purpose, the most purified samples possessing a high melting-point are those most suitable, *hardness* being the quality most essential for candle-making. The crude sample, having the lowest melting-point, may be burnt in a suitable argand lamp, if reduced to a melted condition, and presents some advantages to those who object to the oily nature and odour of paraffine oil and petroleum, as paraffine wax is clean to the touch and perfectly odourless, while it burns with a pure white light that is alike intense and dense in the flame, and is *perfectly free* from danger, for, if spilt or overturned, it immediately solidifies, and may then be peeled off anything it settles on. The drawback to its use is that a mass of it takes a long time to melt, which is inconvenient. The lamp suitable for burning melted paraffine wax is shown in Fig. 90. It consists of a cylindrical reservoir, R, of stout brass, $3\frac{1}{4}$ inches high and $2\frac{3}{4}$ inches diameter, with a thick brass central air-tube, the stoutness of material being necessary to keep the mass of paraffine liquid when once thoroughly melted by the heat conveyed from the flame through the metal-work to the centre of the reservoir.

The wick is fitted to a little ring of brass, from which projects a pin that runs in a serpentine groove cut on the inner side of the air-tube, and drops into a slot cut in a tube, W, placed outside the wick concentric with the air-tube. From the top of this slotted tube a broad flange extends to the outer cylinder of the reservoir, by which the wick-tube is kept in place, and acts as a guide when it is rotated by a stout pin, P, riveted on the upper side of the guide-flange. By this pin the wick can be wound down to the bottom of the reservoir, and the wick can then be cut off even with the top of the central air-tube. Over the top of the cylinder a brass cap fits that carries an oxygenating cone, K, and a screw-gallery, G, that supports the chimney, C. In this cap a hole is cut that fits over the pin, P, so that when it is rotated on the cylinder by means of three ebony balls, B, fixed to its circumference, it likewise rotates the flange connected with the wick-tube, and allows of the wick being raised or depressed to the proper height for perfect combustion. If the height of the chimney has been properly adjusted to this kind of lamp, a short bright flame should be obtained that is perfectly free from smoke; should it smoke, a longer chimney is required. Should the flame be thin, the chimney is too long; if drawn in, the chimney is too long or too much contracted. In this arrangement the wick is somewhat disposed to char. It would be a great improvement if wicks could be made of asbestos. In spirit-lamps I have found that a wick may be made of fine wire (platinum is preferable, though the most expensive) fitted very tight into the wick-holder, when the spirit may be sucked to the summit through the interspaces by capillary attraction; but such an arrangement is not suited for non-mobile liquids, like vegetable oils or melted wax, that moreover tend to clog any such contrivance.

The wax may be melted by cutting it into shreds before filling the reservoir, from which the wick and other parts have been removed, and placing the lamp on the hob, or in an oven; but the better plan is to raise the lamp on the supporting-rod by the adjusting-tube, T, and placing beneath the central air-tube a small flat capped spirit-lamp. The adjusting-tube is attached to the reservoir by a block of wood, S, that serves as a convenient handle when the lamp is hot. The mirror, M, is arranged and adjusted on the sliding tube, T, in the manner previously described.

Animal Oil Lamps.—The lamp most usually supplied with the ordinary phantasmagoria lantern of the shops is a fountain argand, with a flat reservoir, shown in Fig. 91, as in this case the illuminating material may be placed inside the body of the lantern with advantage, the oil being improved by warmth. The best illuminating material is good camphorised sperm oil. Two ounces of camphor should be moistened with a little alcohol, then pounded in a mortar, and to the magma thus produced, a pint of oil added, and stirred till dissolved. The argand burner must be so connected with the reservoir that the point of constant level is about $1\frac{1}{4}$ inches below the top of the wick. The chimney, C, somewhat conical in shape, is fixed to the metal gallery, G, by a brass screw-cap that overlaps a lip on the lower end of the chimney. The gallery also carries the air-cone, K, and in its external ring three slots are cut that drop over three pins terminating in ebony balls, B, B, that spring from the wick-regulator, R R. The wick is placed perpendicularly on a brass "wick-holder," W, from which projects a pin that fits a slot, S, in the "wick-adjuster," R, and also a serpentine groove cut on the inner side of the air-tube, A, of the wick-tube, T T. The wick-adjuster, R, is a tube that drops into the wick-tube, T T, outside the wick, and from the top of this tube springs a flange perforated so as to intercept as little air as possible from passing to the cone, K, as shown in the lower section (Fig. 92). On the slot, S, in the adjuster, R, being placed opposite the upper end of the serpentine groove in the air-tube, A, the pin in the wick-holder will fit into both, and the brass wick-holder will then drop into place between the two, but not in any other position. On rotating the flange from right to left the wick is worked to the bottom of the

wick-tube, T, in which position it must be carefully cut off even with the top of the tube by a pair of sharp "shield-scissors," specially constructed for trimming lamps. On rotating the flange of the adjuster from left to right the wick is raised, and when about one-eighth of an inch above the tube it is in the best position for the brightest, smokeless flame, when the gallery with its air-cone and chimney is fitted over the adjuster. filling the lamp, when both corks must be removed. After time has been allowed for the wick to get thoroughly soaked with oil, it should be lighted, allowed to burn for a few minutes, then blown out and re-trimmed with that exactitude that is essential to secure an even, smokeless, bright flame, and this can be better accomplished after the wick has been slightly charred. If the wick be soaked in strong vinegar, and then thoroughly dried before use, it will not char so readily. It need hardly be said that the metal-work must be kept clean, and lamp-glasses and reflectors thoroughly polished before use. The best reflectors are made of suitable thin concave glasses that have been silvered by Liebig's or Petitjean's process, by a deposit of pure metallic silver (not the ordinary mercurialised tinfoil silvering) on the convex side, protected by an electro deposit of copper. Such reflectors are far more brilliant than the ordinary plated reflectors; they cannot tarnish, and only require wiping with a soft wash-leather to make them ready for use, instead of having to clean them with moistened rouge



The oil is carried from the flat reservoir by the delivery-tube, D, which opens into the wick-tube. An oil-cup, O, for receiving any overflow from the wick, screws on to the air-tube, A, its centre being perforated at a to encourage a free up-draught; the upper surface of this cup is also perforated to admit air to the central tube of the burner. A burette oil-can is a neat and clean contrivance for filling lamps—that is to say, a can from the bottom of which springs a narrow tube that is curved into a long spout on a line just below the neck. One of a pint capacity may be used as a store-bottle, in which case both neck and spout must be corked till required for

worked over with the pad of the thumb, and polish with a leather buff. Such mirrors must be guarded by a metal concave shield of a deeper curve than the back of the reflector, and be perforated to admit air for the purpose of keeping it cool.

Argand Gas Burners.—Until recently "Leslie's burner" held pre-eminence for light-giving qualities. This consisted of a series of small conical iron tubes converging from a broad connecting base in a conical form to a narrower centre. The chimney was arranged with an air-cone, so as to cause an up-draught between the several tubes and upon the flame. The drawback to this form of burner was the liability for the small tubes to become clogged by the corroding action of the gas. The most perfect gas argand at present attainable is the "London burner," a recent patent. It is well known that if house-gas be passed through the vapour of benzole, as recommended by the late Mr. Mansfield, who fell a victim to his experiments, the illuminating power is greatly increased; but the London burner gives a light very nearly equal to naphthalised gas, while the flame is short, cylindrical, steady, very bright and white, but, unless naphthalised, lacking in density. This burner is shown in section in Fig. 93. N, the napthaliser on which it is mounted, serves as a stand; I being the inlet-tap, and R the gas-regulator, a very essential part of this burner, through which it passes by three small curved tubes, T, T, T, to the argand burner, B, which is made of steatite, to render the exit-holes incorrodible, A being the central air-way. Outside the burner is a thin white metal air-cone, K K, supported by a gallery, G G, that also carries the glass chimney, C. The regulator consists of a solid conical point that descends from the top of the brass cap from which the three gas-tubes, T, T, T, spring, which fits into a hollow conical tube, or counter-fitting, that screws up into the cap, so that the flow of gas can be entirely cut off or admitted to full extent, being, in fact, a conical stop-cock that can be regulated to the veriest nicety by rotating the gallery, G G, to the left or to the right, the lower part being firmly screwed to the naphthaliser, N, or directly on to a gas-bracket or other supply-pipe. This regulator must be adjusted till the flame forms a perfectly bright cylinder about 1½ inches high, for if allowed to flare up the chimney the best result is not attained. Any stop-cock attached to the ordinary gas supply must be turned full on as the regulator takes its place, and there must be no check on the supply externally. This burner is made in three sizes: the smallest is suitable for microscopic lamps; the second I prefer to the larger model for magic-lantern work, as it gives a denser flame. The naphthaliser, N, is shown in section beneath. It consists of a cylindrical box, to the lid of which is soldered in a spiral coil a band of zinc nearly the depth of the box, that "beds" in a thick felt pad laid on the bottom, and terminates in the centre just beneath the hollow socket on which the burner is screwed. Benzole is poured in through this opening till the felt pad is well saturated, so that it may keep the spiral passage filled with benzole vapour. The gas passes in by the tap, I, and in its course to the central opening, R, becomes impregnated with the vapour, or, as it is termed, "naphthalised." Another form of "naphthaliser," used for photographic self-registering meteorological apparatus, is shown in Fig. 94. Its arrangement for making the gas pass over a long course of benzole vapour within a small compass is self-evident. The gas enters at I, and passes out at B. It is better to fill the passages with sponge-cuttings, as offering a larger surface from which the vapour can be given off. In winter, this arrangement may be supported over a water-bath heated by a small gas-jet, so as to ensure the vapour being given off during cold weather at a uniform temperature.

Flat Wicked Burners are very serviceable for microscopic illumination, especially if the thin edge, instead of the broad side, of the wick be turned towards the mirror, when fine markings are to be brought out.

A section of one of Dietz's flat-wick burners is shown in Fig. 95. As air is not passed through the centre of the flame, it is projected on to the flat wick by a slot cut in the large air-cone that stands above both wick and the lower part of flame.

Heavy Hydro-carbon Oil Burners are not much employed for scientific purposes; but there is one form of burner, patented by Holmes, that I think might be modified in form and made serviceable for microscopic illumination, as it gives a small but very bright jet of light. A small metal tube is closed at the upper end, pierced with a few minute holes, and packed with coarse lamp cotton. When the wick is saturated with heavy hydro-carbon oil, the end of the metal tube is warmed with a spirit-flame for a few seconds till the oil is vaporised and issues from the holes in the form of gas, when it ignites. The tube is then placed in the reservoir of the lamp, and the little jets continue to burn. Neither lamp-glass nor globe is necessary for this form of burner.

Fish-tail and Bat's-wing Burners.—These well-known forms of gas-jets are useful where glass chimneys would prove in the way, and where the equally compact lime-light burner would be regarded as too elaborate. Two fish-tails placed close behind each other produce an intense light. To prevent flicker through floor-draughts, these jets may be placed within a shallow three-sided box with the front side closed with a plate of glass, air being admitted from beneath by a series of well-distributed holes bored in a block of wood that serves to form the base of the arrangement.

Candles.—Sperm candles are employed as the standard of comparison with other lights; thus we say such a burner equals so many standard candles (six to the pound). Candles are made with single and double wicks implanted in tallow, "palm," "composite," stearine, wax, spermaceti, paraffine, ozokerit, etc. A Palmer's candle in its spring-tube to keep the flame at a constant point is a convenient arrangement for the travelling microscopist, especially if the tube be fitted in an adjusting clamp that can be fixed to the edge of a table, to allow of the point of light being raised or depressed. Night-lights are of great use to the travelling photographer, especially if made with paraffine wax, as a number can be packed in a cylindrical pasteboard case, that can be placed inside a yellow chimney, the whole being enclosed in a tin guard-tube (as shown in Fig. 96A), the lid of the same serving as a cup for the light and a gallery for the chimney when arranged for developing dry plates, etc., as shown in Fig. 96B.

Other Sources of Light.—In concluding the series of articles on "Sources of Light," in which I have endeavoured to describe the best type of each class of illuminating apparatus, it is only right to notice some that I have had no personal experience in, or that may be regarded as little known inventions; thus there is the "Bourbouze burner," which is thus described:—

"The Bourbouze lamp is the name of a new French invention, which gives, it is stated, as much light as the oxy-hydrogen or Drummond lamp, but is very much less costly. The combustible is coal-gas intimately mixed with air. The mixture enters a tube, and then passes through a metallic plate pierced with a great number of small holes, so that the gas is divided into an infinite number of small jets. These play upon a tissue of platinum wire, and it is not until the gas has passed through this tissue that it is lighted. Under the influence of the heat produced, the platinum soon becomes white hot, and it is then impossible to look at it with the naked eye. The gaseous mixture is forced through the system by a slight pressure; about one cubic metre of gas is consumed per hour."

Similar in arrangement is the apparatus of Mr. Hogg, of Edinburgh, which is constructed in the following manner:—"Two tubes are employed on the Bunsen lamp principle, one of which is of smaller diameter than the other, and the said smaller tube is placed within the larger tube. One tube is placed in communication with condensed gas, or air, or with both, such gas or air being compressed by a pump or other suitable apparatus for compressing or condensing air, or gas, or aëriform or gaseous fluid. This pump or apparatus may be of ordinary construction, and may be worked by hand, steam, or other power. The other tube is placed in communication with ordinary arrangements for the supply of atmospheric air or gas thereto. The gas or the air, or both, may be supplied at any determined pressure, or it or they may be condensed or compressed (before reaching the tube or tubes) in a pump or apparatus for the purpose of ordinary construction. The mixture of gas and air is passed through a perforated plate of platina or other suitable material, or a tissue of platina wire gauze, or other suitable wire gauze, by which it is divided into numerous small jets. The mixture of gas and air is obtained thus—that is to say, one of those agents is conducted through the smaller tube and discharged through the opening thereof into the larger tube, into which also the other agent is admitted. The tubes thus act as a sort of blow-pipe. The aëriform or gaseous mixture passes through the larger tube to a piece or surface of fine

platina. Pierced plate, or wire gauze, or woven platina wire, or other suitable metal, may be substituted for the platina. The minute jets pass through the interstices of the platina or other material, and are ignited. The metal soon becomes incandescent, the supply of air being duly regulated, combustion is made perfect, flame disappears, and the platina or metal becomes a surface of intense light. Sometimes, instead of using a mixture of gas and air, compressed or condensed gas by itself and air at the ordinary pressure are used. Sometimes the gas and air may be heated before burning, to obtain a maximum effect."

An arrangement wherein atmospheric air under pressure is driven through a small tube coiled into a spiral and heated by a lamp, passes out at a blow-pipe nozzle through a spirit or house-gas flame on to a lime-ball in the manner of the oxy-calcium jet. Such an arrangement, if effective, would be economical, and save the trouble of making oxygen, while the size of the reservoir would be greatly reduced. I hear this spoken of promisingly, but as yet I fear it can only be regarded as an undeveloped source of light.

TECHNICAL DRAWING.—LXX.

DRAWING FOR BRICKLAYERS (*continued*).

COMMON DOUBLE FLEMISH BOND.

DOUBLE Flemish bond implies that this bond appears on both sides of a wall. In double Flemish bond it is the custom in some parts to use alternate stretching courses on both sides of the wall—that is, courses in which false headers or bats are combined with stretchers. Thus two rows of fissures or un-

Fig.580.

broken joints, each 9 inches in length, and at intervals of 4 inches apart, are produced, one near the face and the other near the back of the wall, each being at the distance of half a brick from the adjacent surface of the wall.

Fig. 580 is the plan of one course of a portion of a two-brick wall, built according to double Flemish bond.

"Hence," says Sir Charles Pasley, "on comparing these two arrangements, it will be evident that both sides of a wall are weak in a common double Flemish bond, whilst in the common single Flemish bond one side of the wall only is defective. The common double Flemish bond is therefore a very imperfect arrangement, which never ought to be used at all, and, to the best of my knowledge, is never used in the walls of a building by any skilful bricklayer. On comparing together the various kinds of brickwork, it appears to me that the common English bond is by far the simplest and strongest, and that it ought therefore to be always used in preference to Flemish bond, which is sure to leave one side of the wall weak, and to a certain degree liable to split by longitudinal fracture."

English bond is not only much stronger in itself than Flemish bond, but it has the great advantage, which the other does not possess, of being able to alternate occasionally in a substantial manner with one or more diagonal courses of brickwork in walls of two bricks in thickness and upwards. This useful arrangement we will now proceed to explain.

DIAGONAL BOND.

In thick walls, but more especially in foundations, a third kind of bond, called diagonal bond, is sometimes used. This consists in laying certain of the courses of bricks at right angles to each other, and oblique to the surface of the wall, with which they form at every part an angle of about 45°*

In adopting this arrangement, intermixed with English bond, the diagonal bricks in those courses do not extend so far as the face or back of the wall, where a line of common heading or stretching bricks is laid in the usual manner: thus the wall, when finished, has all the appearance of common English bond.

A two-brick wall is the thinnest in which diagonal courses can be used combined with English bond, and in this case only with the stretching courses. Figs. 581, 582, and 583 represent this arrangement, in which are introduced, first, a heading course of common English bond (Fig. 581); secondly, a diagonal course between the stretchers (Fig. 582); after this, a second heading

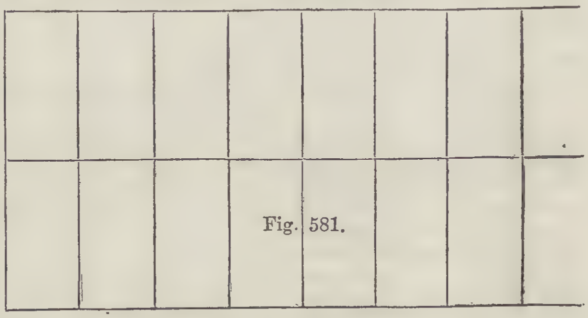


Fig. 581.

course, and then another diagonal course between the second set of stretchers (Fig. 583) at right angles to the former.

The triangular spaces at the extremities of the diagonal bricks between them and the common headers or stretchers at the external surface of the wall must be filled in with bats or fragments cut to the same form.

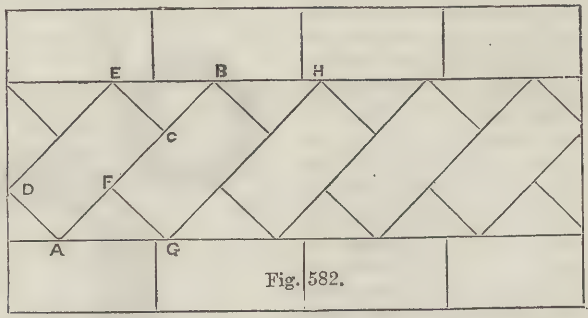


Fig. 582.

Sometimes the bricklayer, instead of using all fragments, will cut the end of a whole brick obliquely, so as to meet the outer row of headers or stretchers, in which the diagonal bricks are enclosed. But this precaution seems scarcely necessary if the interstices arising from the former method be well filled up with solid pieces, instead of being simply stuffed with mortar.

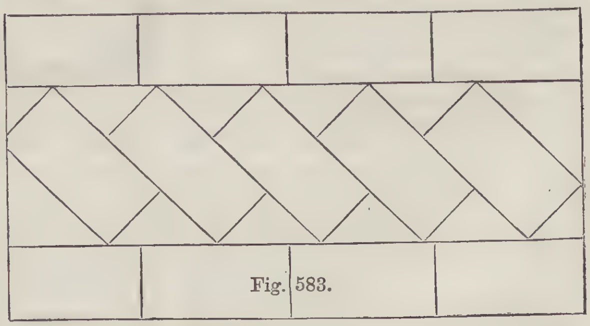


Fig. 583.

Although Figs. 582 and 583 appear very simple, some little care is necessary in drawing them. It must be borne in mind that the bricks, though placed obliquely, are *not altered in their rectangular form*—a fact which students often overlook. The following method is therefore given.

Having drawn the parallel lines representing the total thickness of the wall, and having drawn lines within these at distances equal to the lines of headers or stretchers which are to

* One diagonal brick laid at an angle of 46° 24′ with the face of the wall occupies the space of one header in the thickness. The bricklayer finds the proper angle by trial. The angle of 45° is therefore only approximate, and is here used for convenience in drawing.

form the faces of the wall, draw a line at any point, as A, at 45° to the line of the wall—viz., A B (this will, of course, be done by means of the set-square of 45° worked against the T-square); reverse the set-square, and from A draw A D. The space between these two lines will then be the right angle D A B. Now on A B set off A C equal to the length of a brick, and from A mark off on A D the width of a brick. From C and D draw lines parallel to A B and A D, which meeting in E will complete the rectangle representing the brick, the point E, if the work be correctly done, falling on the line bounding the space to contain the diagonal course.

From B set off B F equal to A C, and from F draw F G; from G draw G H, and in this way the work will proceed.

The use of diagonal courses consists in producing a more powerful bond than the lap of a quarter brick only, which is all that the common English or Flemish bonds are capable of yielding; and there is no possible way of laying the diagonal bricks wrongly, for if they be intermingled with common English bond, according to the rule given, one, two, three, or more whole bricks laid diagonally will just fill up the core of the wall, in proportion to its thickness; and all the successive courses of those bricks will break joint properly, whether in reference to each other, or to the common courses of English bond, above or below them. This may easily be proved by building a wall, as above described, with the model bricks.

The student will observe that in thus combining the diagonal courses with English bond, the same effect will be produced by throwing in the courses of diagonal bond singly, instead of using two in succession. For example, after one course of English bond, might come one diagonal course, then another course of English bond, after which might follow the second course of diagonal bond. But whichever arrangement be adopted, the successive diagonal courses ought to be laid in contrary directions.

Diagonal courses laid as here described are sometimes called "herring-bone bond." This term is more correctly applied to the method by which the direction of the diagonal bricks in the core are reversed in the same course. Diagonal bond is further illustrated in "Building Construction" (Vol. I., p. 172).

FREEHAND DRAWING.

The example here given (Fig. 584) is a design for an ornamental floor-tile. The entire tile would be square. This portion, being half of the whole, consists of course of two squares, each square representing a quarter of the tile, which thus consists of four repeats of the same ornamental form. Having drawn the two squares, proceed to draw diagonals in each, corresponding with A B C D. Draw the centre lobe of the ornament, using A B as the centre line. The curves, turning in a continuous direction, bend outward, and are kept balanced by the line E F, parallel to the diagonal C D. The rest of the figure will be easily followed from the example, care being taken in the exact balancing of the sides.

As it is intended that the student should complete the tile, he should draw the whole square at starting, and divide it into quarters; the diagonals are then to be drawn in each of these smaller squares, and as any single part of the ornament has been sketched in one compartment, it should be repeated in each of the others respectively, until the whole is completed; by this means each line can be singly compared with the others, and thus the balancing of the forms will be facilitated.

When the whole outline has been carefully revised and "lined in," the design may be coloured: the ground may be black and the ornament Venetian red; or the ground may be blue and the ornament orange; or the ground may be crimson and the pattern green, or any such combination, according to the taste of the student. It must, however, be remarked that, since the floor-tile is intended to ornament a perfectly flat surface, no attempt at shading must be made, since shading has the effect of causing the form to appear to be raised, or to stand up from the surface; and it will easily be understood that anything approaching *raised* ornamentation would be out of place on a floor.

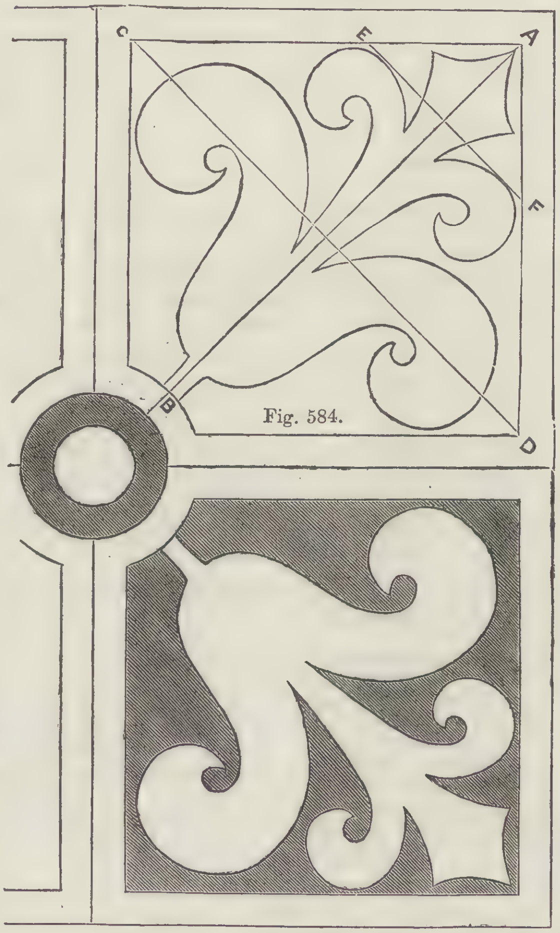


Fig. 584.

The colours used for colouring this and similar designs are not the usual cakes supplied in colour-boxes—though, of course, these would answer the purpose if others cannot be obtained—but, owing to the transparency of most cake colours, it is rather difficult to cover surfaces evenly; and in this example the spotty appearance thus caused is very disagreeable, whilst much time would be spent in "stippling" up the work.

The colours best adapted for this purpose are those called "body-colours." They are sold either in powder, or in some cases, in lump, by the artists' colourmen. These are ground up, first with water, and then with the addition of a little gum arabic, white of an egg, or weak size. Very good body colours may be obtained under the name of "moist colours," in metal tubes, which are found to answer the purpose very well. They are more expensive than the powder colours, but are more finely ground, and are mixed with gum, or other medium, requiring only the addition of water to be ready for use.

LINEAR DRAWING (*continued*).

BRICK ARCHES.

The general principles of arches having been elucidated in "Building Construction," it will be unnecessary here to repeat the lesson. We will, therefore, only remind the student of some technical terms used in relation to arches, such as the *piers* and *abutments*, which support them; also the *span* or width, and the *rise* or height of an arch. The *skewbacks*, or sides of the ring of brickwork, when the arch does not spring from a horizontal plane; the *haunches*, or lower segments of each side, as distinguished from what common bricklayers call the scheme part, or upper segment of the arch; the *intrados*, or whole interior, of the lower surface; the *extrados*, or whole exterior, or upper surface; the *crown*, or summit of an arch; the *voussoirs*, or arch-stones; and the *key*, or *keystone*.

The various kinds of arches—such as straight, segmental, stilted, Gothic, etc.—have also been described in the articles on "Building Construction."

The arches used in buildings of any importance are of two kinds—external and internal.

The former are executed with great care, and in an ornamental manner; the latter are done strongly, but roughly, being afterwards concealed from view by the inside finishing of rooms, etc.

CIVIL ENGINEERING.—XVIII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*continued*).

THE name of Smeaton will ever be associated with the Eddystone. It was upon these weather-beaten rocks, which had already borne two lighthouses, one of which was destroyed by water and one by fire, that the great engineer was to erect the monument which for nearly 120 years has nobly withstood the buffetings of the elements.

It is worthy of note that at the time Smeaton was recommended by the then President of the Royal Society, the Earl of Macclesfield, for the task of rebuilding the Eddystone Lighthouse, he was not an engineer either by profession or education. A philosophical instrument maker by trade, he confesses that when he commenced his designs he was a total stranger to such structures. He had, however, studied very carefully the character of the two previous lighthouses; and whilst he was prepared to retain all the good points in them which presented themselves to his judgment, he was ready to bring his great genius and large stock of common sense to improve upon their weak points, and altogether abandon their faulty ones.

What his views upon the matter were we shall best explain by quoting the drift of his own words. He says, "It appeared evident that had it not been for the courses of moorstone (in Rudyerd's structure) inlaid with the frame of the building, and acting like the ballast of a ship, it would long ago have been upset, notwithstanding all the branches of iron-work contrived to retain it; and that in reality the violent vibration which the late building was constantly subject to, had rendered its base or seat in some degree rounding, like the rockers of a cradle. It seemed, therefore, a primary point of importance to procure, if possible, an enlargement of the base.

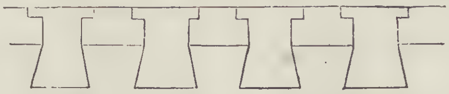


Fig. 39.

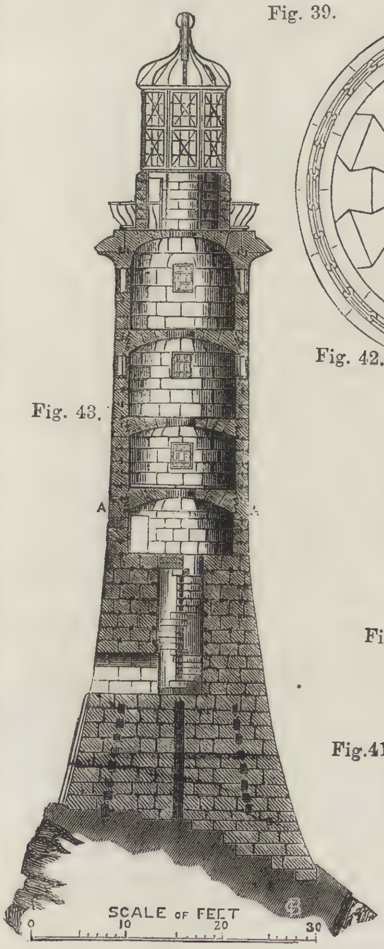


Fig. 43.

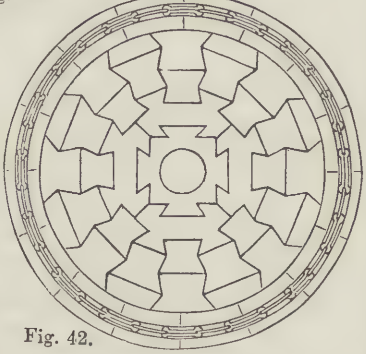


Fig. 42.

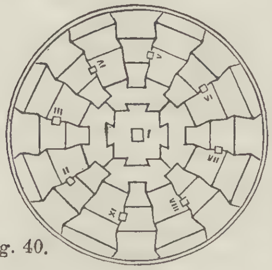


Fig. 40.

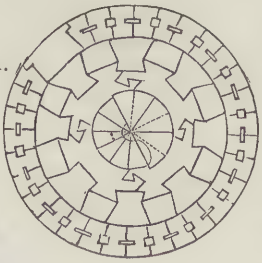


Fig. 41.

It also seemed desirable to adhere strictly to the conical form, or at least to a modification of the conical form." He observes, in reference to the true cone, "The necessary consequence would be, that the diameter of every part being proportionally increased by an enlargement of the base, the action of the sea would be greater upon the building in the same proportion; although as the strength increases in proportion to the increased weight of the materials, the total absolute strength to resist the action of the sea would be greater by a proportional enlargement of every part, *but would require a greater quantity of materials.* On the other hand, if we could enlarge the base, and at the same time rather diminish than increase the size of the waist and upper works, as large an amount of strength and stiffness would arise from a larger base, accompanied with a less resistance to the acting power, as if a similar conical figure had been preserved, whilst at the same time *a less quantity of material* would be employed." A stone edifice having been determined upon, the engineer, following up the mode of reasoning stated, decided upon giving his structure the waist of a large spreading oak. He made a model in wood, having a small degree of tapering, and then fitted it to the oblique surface of another block—the surface of the Eddystone being sloping—and found that by arranging the several curves, they could be firmly united to form an efficient foundation. The model having given satisfaction, the works were ordered to be commenced forthwith.

Before proceeding further with an account of the construction of Smeaton's lighthouse, we wish to direct the attention of our readers to the paragraphs we have italicised. It will be observed how careful the engineer was to avoid the unnecessary employment of material, and by what a happy train of reasoning he arrived at the method of doing so. Well would it be if, upon every occasion, the engineer sufficiently studied the design he has to carry out, and the work he has to do, as that just so much material as is necessary should be employed, and no more. It is an absolute fact that there are many engineering operations which are actually *weakened*, by the unnecessary employment of material. The work is burdened with weight, and the material which adds to the weight adds not the least atom of strength to the design; expense is unnecessarily incurred, and often the design is rendered clumsy and unsightly. We purpose referring more particularly to this important feature in engineering works, the useless employment of material, in a subsequent paper.

Having definitely decided upon the material to be employed, and the form to be given to the lighthouse, Smeaton's thoughts were next directed to the best method for uniting his stone blocks. He had, after careful inquiries in the neighbourhood, decided upon using moorstone for the basement and lower portion of the building, and Portland stone for the upper portion. Accordingly, he contracted for 240 tons of the former, at 25s. per ton roughed out, and 4d. per foot superficial for working the beds. This price, however, did not include the cost of conveyance to the rock, but only to the yard at Plymouth. The moorstone is taken out of the quarry by splitting it with a number of wedges driven into notches or grooves cut in the surface about 4 inches apart, more or less, according to the size and strength of the block. The holes are sunk with the point of a pick. The mode of quarrying the Portland stone has been alluded to in our description of the Portland Breakwater. The manner of uniting the blocks deserves careful attention. At first Smeaton's thoughts were directed to iron cramps, but after mature thought this plan was rejected; then the idea of dovetailing, as employed in woodwork, occurred to him. He had seen something of the kind in a description by Belidor of the stone floor of the great sluice

at Cherbourg, where the tails of the upright headers are cut into dovetails, for their insertion into the mass of rough masonry below. (See Fig. 39.)

"From these beginnings," he says, "I was readily led to believe, that if the blocks themselves were, both inside and out, all formed into large dovetails, they might be managed so as mutually to lock one another together, being primarily engrafted into the rock; and in the round and entire courses above the top of the rock they might all proceed from, and be locked to, one large centre stone. It is obvious that by this method of dovetailing, while the slope of the rock was made good by cutting the steps formed by Mr. Rudyerd also into dovetails, it might be said that the foundation-stones of every course were engrafted into, or rather rooted into the rock; which would not only keep all the stones in one course together, but prevent the courses themselves, as one stone, from moving or sliding upon each other. But after losing hold of the rock by getting above it, then, though every stone in the same course would be bonded in the strongest manner with each other, and might be considered as a single stone, which would weigh a considerable number of tons, and would be further retained to the floor below by the cement, so that, when completed, the sea would have no action upon it but edgeways; yet as a force, if sufficiently great, might move it, notwithstanding its weight, and the small hold of the sea upon it, and break the cement, before time had given it that hardness which it might be expected to acquire afterwards, I had formed more expedients than one for fixing the courses to one another, so as absolutely to prevent their shifting." Such is Smeaton's description in his own words of the method he proposed to adopt in uniting the component pieces of his work, and the reason of his doing so. We shall see how well he carried out his purpose.

The mortar used was compounded of blue lias lime and puzzolana in equal quantities, prepared by beating it up in a strong wooden bucket with a wooden pestle. The lime, in quantities of a quarter of a peck at a time, was beaten first, and when formed with sea-water into a thin paste, the puzzolana was gradually added whilst the beating was continued.

The system of dovetailing determined upon, necessitated an immense amount of labour upon each individual block, and the accuracy required in fitting the pieces together rendered it desirable to arrange each course in a completed state, which could then be taken to pieces for transport to the rock. Application was made to the Mayor of Plymouth to permit the temporary use of one of the municipal buildings for the purpose of fitting the courses together, but it was refused; and a shed was hired for the occasion. The greatest care was requisite to prevent any confusion in the relative position of the stones. For this end, each stone was marked or numbered, and lines were drawn across the middle of each tending to the centre. The result of this precaution was that no difficulty or delay occurred in bedding the stones into their position upon their arrival at the rock. We subjoin plans of a few of the courses, showing the method of jointing adopted. Fig. 40 represents the first course, which was composed wholly of hewn stone. It is the seventh from the bottom course, which latter consisted only of four hewn stones, lying as it did at the bottom of the slope of the reef. The stones increased gradually in number in each course from the bottom until the seventh was reached, consisting of four, thirteen, twenty-five, twenty-three, twenty-six, and twenty-six stones each respectively. As one stone or more of each of these six bottom courses were engrafted in dovetail recesses cut into the solid rock, there could be no danger whatever arising from the horizontal force of the sea acting against them; but the seventh course rising entirely above the rock, a plan was adopted by the engineer for producing an artificial arrangement which should cause a similar effect. This plan was as follows:—In the centre of the sixth course, and in eight regular positions around this centre, holes were cut in the stone 12 inches square. The centre hole was 13 inches deep, and the remaining eight were 6 inches deep. Into these nine holes, blocks of hard marble from the Plymouth rocks, 12 inches square, were introduced, and securely fixed in their positions by mortar and wedges. Corresponding holes to these marble blocks were cut in the proper stones of the seventh course, as shown by the figures in Fig. 40; and the projecting ends of the blocks were introduced in them, and were thus most immovably fixed against any force acting horizontally.

In this manner seventeen more courses were carried up, the whole being solid, with the exception of the winding staircase and entrance doorway, which commenced on the fourteenth course from the bottom. A height of 27 feet above ordinary spring-tide high-water mark was thus attained, and at this point the hollow or habitable portion of the building commenced. In Fig. 41 we give a plan of the twenty-fourth course, in which the dovetailing arrangement of the exterior stones is shown. This system was adopted at this stage, because the building lacked the benefit of the interior stones to tie the several courses together. The diameter of the building immediately above the rock is 25 feet, but at the course shown in Fig. 41 it was reduced to 16 feet 8 inches, the rooms being 12 feet 4 inches in diameter, and the walls 13 inches thick. The walls were composed of single blocks of moorstone, sixteen in each course, cramped with iron, and joggled at each joint. The joggles are of sawn marble 8 inches long, 4 inches broad, and 3 inches thick.

At the twenty-eighth course the vaulted floor forming the ceiling to the upper store-room was introduced, and into this course was laid the first circular iron chain, which was lodged in a groove cut round the middle of the upper surface of the stones. The necessity for this chain, shown in Fig. 42, which represents the twenty-ninth course, marked A A in the section (Fig. 43), will be apparent from the nature of the construction of the floor resting upon this and the course above.

By reference to the section it will be seen that each floor rests upon two courses, and although arched it has not the benefit of sloping abutments to support it. Had each floor consisted of a single stone, there would have been no outward thrust to provide against; but being made in pieces, it had the same tendency to thrust the encompassing walls outwards, as the component stones of an arch; although, irrespective of the encompassing chain, the system of dovetailing which was also introduced in the floors tended to mitigate the evil of the lateral pressure.

Smeaton adopted the endless chain by a consideration of its value in the cupola of St. Paul's Cathedral, where it had been introduced by Sir Christopher Wren. Each of the floors is encompassed by two endless chains, the bars or links of which are $1\frac{1}{2}$-inch square, and the grooves receiving them are 4 inches deep and wide. After each chain was laid in the groove 11 cwt. of lead was run in.

The height of the main column containing forty-six courses is 70 feet, and its diameter at the top 15 feet. The lantern is formed almost entirely of copper. It consists of sixteen frames, with nine panes of glass in each. The lantern is 24 feet high, and the diameter 9 feet. The light was originally derived from a chandelier 6 feet 4 inches in diameter, to contain sixteen candles; and a smaller one within and above it, 3 feet 4 inches in diameter, to contain eight candles. In 1807, however, the chandeliers were removed, and a reflector-frame substituted, fitted with argand burners, and parabolic reflectors formed of copper, covered with highly polished silver.

Smeaton completed this elegant and substantial building in rather less than three and a quarter years.

We shall present to our readers the description of another lighthouse, as being an excellent specimen of marine engineering, the Bell Rock Lighthouse, erected by Mr. Robert Stevenson. The Bell Rock is situated in the German Ocean, eleven miles S.W. from the Redhead, in Forfarshire. The rock is a red sandstone, the surface being very rugged and full of cavities. The north-east end is the highest portion of the reef, and is partially left dry at low water of neap tides, but the lower level is only visible at springs. The spring tides here rise and fall 15 feet, and the neaps 9 feet.

In 1806 an Act of Parliament was passed to construct a lighthouse upon this rock, and it was decided by the Commissioners to adopt a design similar to the Eddystone. Owing, however, to the nearer coincidence of level between the Bell Rock and the mean level of the sea, as compared with the Eddystone, the operations were greatly more difficult at the outset. The commencement of operations was ushered in by mooring a vessel, fitted out as a light-ship, about one and a-half miles N.E. of the Bell Rock, to be employed as a tender during the first season's operations, to which the artificers retired

whilst the rock was covered with water. The distance of the nearest land from the rock being so great, and the set of the tide so strong, the advantage of a place of refuge at so short a distance is obvious. The light-ship was moored in twenty-two fathoms of water, her moorings consisting of a mushroom anchor weighing 33 cwt., and a heavy chain, to which she was attached by a hempen cable 14 inches in circumference; and at these moorings she rode without accident for four years. The method of lighting this light-ship was peculiar. The vessel had three masts, and each mast was fitted with a cylindrical lantern, the mast passing through its centre. Each lantern contained ten lamps, with as many silver-plated reflectors, arranged around the mast, so that on no side was the light obscured.

Early in 1807 stones were collected from the granite quarries of Rubeslaw, in Aberdeenshire, for the *outside casing* of the first 30 feet from the base, whilst sandstone for the interior or hearting of the solid portion, and for the upper portion of the building, was procured from Mylnefield quarry, near Dundee. The cornice and parapet wall of the light-room were prepared at Edinburgh, and the stones taken from Craigleith quarry. A piece of ground at Arbroath was leased for a work-yard, and here materials were laid down, and workmen collected; sheds also were constructed, and a barrack erected for the accommodation of about 100 artificers. Operations were commenced at the rock itself in August, 1807.

MAP AND PLAN DRAWING.—II.

By C. C. King.

SCALES — COMPENSATING INSTRUMENT — TRIANGULATION: BASE-LINE OF SURVEY, ETC.—SURVEYING CHAIN—LEVELLING—CONTOURING—DELINEATION OF MAPS AND PLANS.

So far, then, we have only obtained a single definite point on the actual surface to be surveyed, and the means of transferring it relatively to the paper on which the projected meridians and arcs of latitude are drawn. The results of the various steps which have now to be taken may either be immediately represented as they are taken, which would only occur in smaller surveys, or, when calculations and corrections have to be entered into, this may be deferred till the work is more advanced. Ultimately, however, the representation must be produced, and then the question of the scale to which the map is to be made has to be considered.

A scale is merely the relation that exists between any dimension on the true surface, and the same as represented on the map. The size of the map, therefore, entirely depends on the scale that is selected, and this is again determined as a rule by the size of the paper on which the map is to be drawn. Thus, if the extreme limits of the area are 1,000 miles laterally, and the size of the paper is about a foot square, the scale will have to be one of 1,000 miles to 10 inches, suppose, or 100 miles to the inch; by which it is inferred that every inch on the map corresponds to 100 miles of true measurement, and that if therefore the inch be divided into 100 equal parts, each one may be considered to show the relative value of one mile on our paper. This is the principle on which scales may be constructed, and practically are so on smaller sketches where the space available for drawing is the chief consideration; but there are numerous scales already prepared for convenience' sake on the ivory or wooden protractors and "scales" in every box of mathematical instruments to suit ordinary maps. Thus we usually find the inch divided into 20, 30, 35, 40, or 45 equal parts, representing so many different proportions of miles, yards, or feet to the inch, and numerous other subdivisions of the same unit, such as twelve parts to the inch, useful in a large scale where feet and inches alone are the principal dimensions. In English maps the "scale" is usually denoted as one of so many miles to the inch: thus in the Ordnance Survey we find one mile to the inch; but in Continental maps it is represented by a fraction, giving the ratio of the map to the actual area, as, for example, $\frac{1}{1000000}$ or $\frac{1}{63360}$. The latter fraction is but another method of defining one mile to an inch; for

The ratio of the map : the true area : : 1 : 63,360.
: : 1 inch : 63,360 inches.
: : 1 inch : 1 mile.

In either case, the scale is actually drawn on the map, a convenient length being taken which is divided into the required number of parts, and if it be large enough, the left-hand division is further marked off into a certain number of small ones, to admit of more minute measurement. Thus if the principal divisions show lengths of ten miles, the first will contain ten equal and smaller portions. Standard atlases generally contain two or three scales for different purposes, as, for example, those of geographical or Italian miles, of which there are 60 to a degree; French kilometres of 111·307 to a degree; German geographical miles of 15 to a degree; and lastly, the scale which is appended to every English map, the statute mile of 69·16 to a degree.

The scale then being determined, the survey can be proceeded with. The base-line has to be measured, and carefully aligned, so that its length and position may be marked on our skeleton map, as well as furnish one absolutely accurate side for the first triangle of the triangulation. For this purpose a theodolite, of large size usually, is fixed at one extremity of the base, and remains there during the whole of the operation, to prevent any lateral deviation from the straight line during the measurement. Rods are planted in the ground at intervals of from a half to three-quarters of a mile, and the inner edges of these are carefully aligned by means of the telescope of the instrument. The starting-point is marked by a block of stone carefully fixed and levelled, and having on its upper surface a metal plate containing a minute point carefully marked.

Various materials have been used for measurement, owing to the absolute necessity for exactitude, and the difficulty of regulating or calculating the alterations made by the expansion of the measuring bar at different times of the year or even at different times in the same day. Thus steel chains, glass, platinum, or deal rods made into rigid wands, have been employed in various instances, and the latter material was used in the re-examination of the Hounslow Heath base, first determined by steel chains in 1784; but in using any of these the temperature has to be noted as every chain is laid, for the expansion of the materials varies with the temperature, and there was at that time no arrangement for making the instrument itself correct its own inaccuracies from this cause.

A more perfect apparatus has been devised for modern surveys, which approaches as nearly as possible complete accuracy. It is a compensating instrument, the construction of which is based on the principle of the unequal expansion of metals. Two rods of iron and brass, about ten feet long, are welded together at their centres, and laquered so as to equalise the influence of the variations of temperature on them. At their extremities are attached two tongues of iron, fixed at right angles to the bars and projecting beyond them, and on their outer parts a minute point of platinum is inserted. The action of the expansion is as follows:—

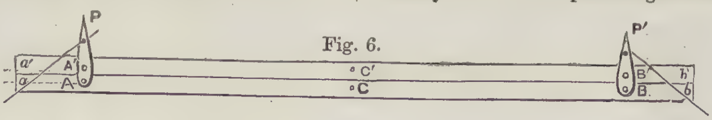


Fig. 6.

Let A B and A′ B′ (Fig. 6) be the two rods united at C C′, and let A P and B P′ be the metal tongues. Now A′ C′ and A C are equal to one another at a given temperature; but if the rods expand to the points a' a and b' b the position of the points P and P′ are unaltered. For assume the increase of temperature to be t, and the coefficient of expansion to be m; then

$$\text{A}a = \text{AC} \,.\, m \,.\, t\,;$$
$$\text{A}'a' = \text{A}'\text{C}' \,.\, m \,.\, t\,;$$
$$\therefore \quad \frac{\text{A}a}{\text{A}'a'} = \frac{m}{m'} = c\text{, a constant.}$$
$$\text{But} \quad \frac{\text{PA}}{\text{PA}'} = \frac{\text{A}a}{\text{A}'a'}\,;$$
$$\text{Therefore} \quad \frac{\text{PA}}{\text{PA}'} = \text{a constant.}$$

That is, A P is independent of the temperature t; and even though expansion occurs, the position of P, or P′ by similar reasoning, remains unaltered.

The distance P P′ is accurately adjusted in the construction of the instrument. These rods are then placed in boxes for the sake of preservation, the points or tongues projecting beyond them, and levels and telescopic sights are fixed to these outer casings both to align the successive bars and level them. They are carefully set up on small platforms resting on trestles, and aligned and levelled by means of "small motion" screws. Five of these instruments were used in the measurement of the Irish base, and after being brought into the alignment another instrument was employed to overcome the difficulty of bringing the points of any two bars in exact contact or juxtaposition. A powerful double microscope, fitted in a compensating frame, of similar character to that of the bars themselves, was placed between two bars. Spirit-levels were attached for adjustment and a telescope for alignment, and the two lenses of the instrument, which were exactly six inches apart, were furnished with micrometric screws, which enabled one of them to be focussed over the platinum point at the extremity of a bar. The microscopes being rigidly fixed to one another, so as to preserve their relative distance, the point of the adjacent bar was brought beneath the lens of the remaining microscope by means of the small motion screws provided to give the measuring rod a slight lateral motion. Thus five bars, giving a length of fifty-two feet, were laid at one time, and the rate of progression was about 250 feet per day. In order to transfer the extremity of the last measurement taken on each occasion to the ground, and enable the work to be carried on the following day, a microscope with a long focus was fixed mid-way between those above described, and a block of stone protected by an iron cover, in which there was a brass disc containing a small silver plate, was securely embedded in the earth, immediately below the focus of the central microscope of the frame. Extreme care was taken lest this should be disturbed, and it was therefore covered at night by a wooden cover and watch kept over it.

Thus the base-line of the survey is most carefully determined, and even if a sufficient length cannot be obtained by actual measurement the length can be extended, provided a considerable line has been measured, by a system of triangulation based on the portion already traced. The accompanying figure (Fig. 7) will explain this. The only thing to be noticed is that the points E, F, G, H, I, J, are clearly visible from the starting-point A, and are nearly at right angles to the points D, K, B, which have been carefully noted and fixed during the measurement. The various parts of the triangles are thus determined, until finally the measured base A B is extended by calculation to the point C (Fig. 7).

Before the base can be considered complete it is reduced to the horizontal plane, if there are any irregularities in the surface over which it has been conveyed, and finally to the level of the sea. This is necessary in accurate work, as the arc actually determined is greater than that which would be measured on the surface of the sea, to which all heights and dimensions are referred, on account of the sphericity of the earth.

Having completed the determination of the base-line, the more prominent or most central and convenient points are fixed for the greater triangulation. Powerful theodolites are used for this purpose, and care is taken that the triangles are as nearly equilateral as possible, so as to avoid the inaccuracy taking very acute angles would induce. The theodolite is simply a telescope fitted on a stand, and capable of receiving movement in a vertical plane, for which purpose it rests in a support, provided with a vertical graduated arc working on carefully adjusted points, and also partaking of a horizontal movement. This is arranged by having the upper telescope frame referred to fixed on a metal disc, having a vernier, which works smoothly and accurately on a lower one, which is graduated on its circumference from zero to 360°, and which admits of being levelled by means of vertical "plate" screws. Two spirit-levels at right angles to one another are fixed for this purpose on the upper plate, which is moreover bevelled or chamfered on the edge to form a sloping surface on which the angular measurements taken can be the more easily read.

The triangulation proceeds from the base-line in a series of gradually increasing triangles, and these are repeatedly taken, their means carefully calculated, and their reduction to the true surface completed by mathematical calculation. A very large theodolite is used for this portion of the survey, and as the distances between the points of the triangles were frequently very great, or, as in the case of the distance between London and Shooter's Hill, much obscured by the smoke of the City, an ingenious device was employed to enable these long sides of the triangles to be ascertained. A reflector is placed at one of the points, and constantly moved so as to reflect a ray of light in the known direction of the other extremity of the line. The observer there directing the telescope of the theodolite in the direction of the reflector, moves the instrument over a very small field by means of the "small motion" screws, until a ray of light is reflected into it; the telescope is then allowed to remain stationary until a second ray verifies the accuracy of the preceding observation. Great distances have been readily fixed, and points forty-five miles apart have been thus determined.

When the greater triangulation is completed, the minor points, those of less importance, are united by a series of smaller triangles, until we can finally mark down on the map the relative position of all the prominent natural and artificial features of the area, the whole of which, with the exception of the base-line, have been fixed by mathematically corrected trigonometrical calculation. The remainder of the work is done by absolute measurement with a chain, the small theodolite being still used for correction, and to determine the bearings of the points with regard to those of the greater triangles.

Fig. 8.

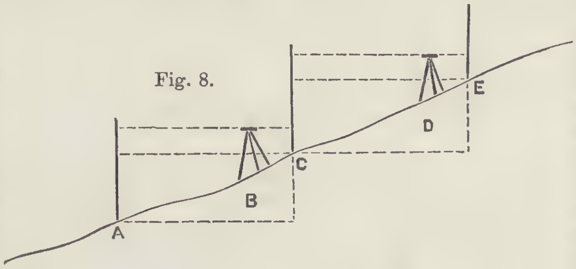
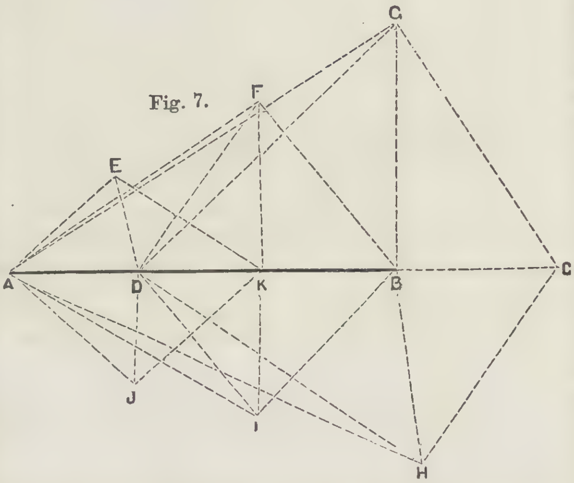


Fig. 7.



The surveying chain is a metal chain composed of iron wire links, one hundred in number, connected by oval rings, the extremities being terminated by swivels and open handles. It is divided into ten equal parts by pieces of brass which are loosely attached to the chain, and which are divided at their outer ends into as many projections as will indicate the number of links at these points from the ends of the chain. In using it it is carefully stretched straight, and the workman carrying the front end marks the point at which the extremity rested by a small metal rod or arrow of which he has ten, and the second surveyor, after advancing to the point and aligning his end of the chain with it, removes the arrow and carries it until the whole ten remain in his hand. This serves to correct the number of times the chain has been used in any measurement, as it would be at any time indicated by the number of arrows. Corrections have to be made for temperature and for sloping ground, and much skill is required, and frequent adjustment of the chain to a standard measure is essential to accurate work.

By these means the whole of the area treated as a plane sur-

face—that is, without reference to its differences of level—will be mapped. It now remains, therefore, to find the different altitudes of the various elevated portions, and to ascertain further the position and character of different levels taken throughout the country, and which serve to determine the shape of the physical features. The former are obtained by levelling, the latter by contouring.

Levelling means the method of ascertaining the altitudes of any points above the surface of the sea, which is called the "datum level." In England the datum level is that of the mean tide at Liverpool. It is conducted by means of a theodolite, either by taking the angles of elevation or depression from point to point, which necessitates much correction for the curvature of the earth and for refraction, or by the more correct and general method of using the instrument as a spirit-level. Other instruments, which, as their names denote, are merely telescopes capable of being accurately adjusted horizontally, such as the Y level and the "dumpy level," are frequently employed for the same purpose. It is usual to start from one of the "bench marks," that is, one of the points of the greater or lesser triangulation which has been carefully marked on a fixed stone or a building. A levelling rod, which is a telescopic bar made thus for portability, so as to obtain as long a rod as possible with but little inconvenience, and which is graduated in feet and inches, is placed perpendicularly on or close to this point A (Fig. 8), and the theodolite stationed in some convenient position, B, is levelled, the telescope directed on it, and the reading in feet and inches noted down. The rod being now removed to a position, C, higher up the slope, the reading is again taken without removing the theodolite, and the difference between the two observations manifestly shows the difference of level of the two stations fixed by the levelling staff. This, if continued, will ascertain the required altitudes, and is, roughly speaking, the principle of levelling, though there are many minor operations connected with it which serve to correct inaccuracies.

Contours are only shown in maps of very large areas, when an orographic map is alone required to show the relative heights of mountain chains. It would, unless a very large scale is used, tend to encumber the paper with too much detail; but as sections are frequently determined by it, and in some small surveys it is often employed to portray conveniently the shape of the physical features, it will be necessary to examine briefly the method of operation. If we imagine a line to be traced round the coast of a country at its datum level on the sea, a continuous curved line, marking the form of all the features, will be produced. If again we assume the sea to rise to a certain height, and then for a similar line or contour to be made, and so on at regular intervals, a series of curves, finally becoming closed curves more or less concentric, will be obtained, which will at each of these levels delineate completely all the hills and valleys, plateaus, and intricacies of every portion of the country. Contouring consists in tracing out and depicting these lines, and is performed practically by a levelling staff and small theodolite. The latter is stationed at a point whence a view over a large area can be embraced, and the staff is placed at a certain point, the altitude of which has been ascertained previously, and through which it is purposed to make the contour pass. The theodolite carefully levelled is directed on it, and the reading in feet and inches taken, after which the levelling staff is removed to a successive series of points, at each of which it is gradually moved up or down the slope, until the wires in the telescope of the theodolite or level again cut the same height on the staff as they did at the first operation. Manifestly the points on which the staff rested are therefore on the same level, and are marked with small pickets. The positions of these are determined by the chain, and by taking their relative bearings with the theodolite, and the small intervening spaces are sketched so as to complete the contoured line.

Thus the entire delineation of the area, its features, its towns or villages, the direction of its roads, if the map be a topographical one like the Ordnance Survey of the United Kingdom, have all been determined, and by the use of the scale can be transferred to our paper. Even in large atlases but a small portion of this information can be delineated for want of space, and the towns and cities and the river-lines, or mountain chains, can only be given. The amount of information that can be given by a large scale will be more fully referred to in considering the construction of a "plan;" but in the maps of countries such as France or Russia, depicted on scales suitable to ordinary atlases, there are but few noticeable points.

The sides of the map show the number of degrees in the parallels of latitude, for every five degrees generally, the arcs themselves being designated by the numerals, and the intermediate spaces being subdivided into the number of degrees lying between each arc. The top and bottom of the map show in a similar manner the degrees of longitude, and thus by marking the intersection of any of these co-ordinates, the latitude and longitude of given points may be found. Rivers are marked by a single irregular line if small, and by a double line if large, on maps of great dimensions; while the character of the cities is shown by the letters by which their names are expressed. Thus capitals or places of the first rank are marked in Roman characters; towns of the second rank in smaller type, but still vertical lettering; while places of less note are designated in small type with slanting or italic lettering: thus, **BERLIN**, SMOLENSK, *Salisbury*.

The mountain ranges are represented by fine lines, nearly parallel at first, commencing at the summits of the hills, where they are usually dark, and extending approximately to the plains, where they become lighter and more divergent. These lines are called *hachure* lines, and represent the course that would be taken by rills of water trickling from the summits to the plain. They are invariably used in the larger species of maps, as they interfere but little with the general clearness of the representation.

NOTABLE INVENTIONS AND INVENTORS.

XXVIII.—SIR ISAMBARD BRUNEL.

BY JOHN TIMBS.

THE lives of the two Brunels, father and son, were for more than half a century strikingly identified with the progress and the application of mechanical and engineering science.

The elder Brunel, Isambard Mark, was born in 1769, in Normandy, at Hacqueville, a few miles from Rouen. His parents, who were respectable agriculturists, had four children, of whom Isambard was the eldest. He was intended for the priesthood, but from his earliest boyhood showed a decided inclination for mechanical pursuits; and when at the college of Gisors he would steal away to the village carpenter's shop, and draw faces and plans, and learn to handle mechanical tools; and it is related that one day, seeing a new tool in a cutler's window, he pawned his hat to purchase it. He was next sent to the seminary of Nicaise, at Rouen, where he preferred the study of exact sciences, mathematics, mechanics, and navigation, to the classics. In his play-hours, he loved to watch the quay; and seeing some large iron castings landed from an English ship, he inquired whence they had been brought, and on being told from England, the boy exclaimed, "Ah, when I am a man, I will go and see the country where such grand machines are made." On his return home, though only twelve years of ago, he was already a proficient in turning, in the construction of models—ships, machines, and musical instruments—and is stated to have invented a nightcap-making machine, which is still used by the peasantry in that part of Normandy. He also made an octant, guided by the one belonging to his tutor, and by a treatise on navigation; and at the age of fifteen he took such interest in astronomy as to observe the stars, greatly to the astonishment of the villagers. All this precocity was little gratifying to his father, who would have preferred to see his son in the church or in some merchant's office.

Brunel next passed some time in the family of M. Carpentier, a friend of his father, at Rouen, and went through a regular course of lessons in drawing, perspective, and hydrography. Influenced, probably, by M. Carpentier, who had been a trading captain, Brunel enlisted as a sailor in 1786, from which date up to 1793 he made several voyages to the West Indies. He was remarked for the skill, intelligence, and good humour with which he discharged a seaman's duties. He used instruments of his own construction, and while making a pianoforte, when the ship once lay at Guadaloupe, he also made for himself a quadrant in ebony. His ship having been paid off in 1793, Brunel went to Paris, where he got embroiled in the fury of the Revolution; but he escaped to Rouen, and thence fled to the United States. At New York he joined a party of his countrymen

who were about to explore the shores of Lake Ontario to survey the lands of a French company. Brunel led the party of seven persons encamped in the woods, and found a charm in the adventurous work. In 1794 he was appointed, conjointly with one of his fellow-explorers, to survey the canal which now connects Lake Champlain with the river Hudson at Albany. With this work Brunel's career as an engineer may be said to have begun. He next sent in a design for the Houses of Congress, which, though acknowledged as the best, was rejected as too costly and magnificent for simple republicans. He afterwards acted professionally as an architect; and, among other works, built and fitted up the Park Theatre, New York, since burned down. He was appointed chief engineer for New York, and was there employed in the erection of the forts for the defence of the city, and in the establishment of an arsenal and foundry, where his ingenious contrivances for boring cannon and moving large masses of metal with facility showed how successfully he could bring new ideas to bear on the work immediately in progress.

Brunel left New York in January, 1799, and landed in Falmouth in March, where he met Miss Sophia Kingdom, with whom he had become acquainted when in the family of his friend Carpentier at Rouen. This acquaintance, and a desire to work among the scientific engineers of Europe, drew him to England. He married Miss Kingdom shortly after his arrival. He brought with him to England an autographic machine for copying maps, drawings, and written documents; a machine for twisting cotton thread and forming it into balls; and a machine for trimmings and borders for muslins, lawns, and cambrics.

In the accounts of Brunel's inventions, it is stated that the idea of making block pulleys for ships by machinery first occurred to Brunel while he was in New York; but the accuracy of this statement is denied, as we shall presently show. He was employed by Government to carry the plan into execution in the dockyard at Portsmouth. The contrivance comprises, so to speak, sixteen different machines, all driven by the same steam-power, seven of which cut and shape logs of elm or ash into the shells of blocks of any required size, while nine fashion stems of lignum-vitæ into pulleys or sheaves, and form the iron pin, which being inserted, the block is complete. Four men with this machine turn out as many blocks as fourscore did formerly, and at less cost. The supply has never failed, even in time of war, though 1,500 blocks are required in the rigging of a single ship of the line. This machinery, erected by Maudslay in 1804 at Portsmouth, though very complex, in twenty-five years required no repairs. It cost £46,000, and the saving per annum in time of war has been £25,000. A second set of machinery was executed in 1807 for the dockyard at Chatham. There is also a set of magnificent models of this invention in the possession of the Navy Board. The machines work in succession, so as to begin and finish off a two-sheaved block, four inches in length, in the most perfect manner. The entire details of this machinery would far exceed our limits; but the principal parts of which it is composed are clearly described in the first supplement to the *Penny Cyclopædia*.

As to the claim for the invention, when the models were exhibited at South Kensington in 1864, it led to the repetition of the statement that the machinery was invented by Brunel, to which a correspondent of the *Times* replied:—

"Sir Isambard Brunel did not invent, nor did he ever claim to have invented, the block machinery which he had a share in putting up at Portsmouth. The original invention, or series of inventions, was by two men, father and son, each named Walter Taylor, natives of Southampton.

"The beginning was rather more than a century ago" (this was written in 1864), "and was made by the father, who had been at sea, and had been practically impressed with the inefficiency of the blocks in use in his time. After a time they took out a patent for part of their inventions, and subsequently a second patent. These included friction-wheels and circular saws, both of which we owe to the Taylors. During the continuance of their patents, they, under contract, supplied the Government with blocks for the Navy, and for some years they were the only blocks used in the Royal Navy. When, towards the close of the last century, their patents expired, they wished to obtain an extension of them; but the Government objected, and decided for setting up the machinery for themselves.

"Mr. Walter Taylor, the son, who was then making his blocks at the Wood Mills, South Stoneham, near Southampton, generously offered to the Government every facility for the purpose. The Government employed two clever young men to set up the machinery, one of whom was Mr. (afterwards Sir) Isambard Brunel, and the other Lieutenant (afterwards General) Bentham, R.E. With the benefit of Mr. Taylor's explanations, these two young men examined his machinery, and then proceeded to set up machinery on the same principle at Portsmouth.

"Having the resources of Government to back them, they improved the details of the machinery, using for it steam-power instead of water-power, by which Mr. Taylor's mills were worked; but in every essential point the block machinery at Portsmouth is the invention of the Messrs. Taylor. General Bentham's share in the improvements has been forgotten as much as the Messrs. Taylor's original invention.

"Some years ago the specifications of the patents were printed in the *Builder*, and they will enable any one of a mechanical turn of mind, who wishes to ascertain how far Messrs. Brunel and Bentham were indebted to the Messrs. Taylor, to do so easily. The originality of the invention was more than once publicly claimed for the Messrs. Taylor during the lifetime of Sir I. Brunel, and the claim was never contested by him or General Bentham, although General Bentham's widow objected that too little credit had been assigned to her husband."

Mr. Brunel next built in Chatham dockyard the steam sawmill, subsequently improved for cutting veneers, by which double the usual number could be obtained. A popular writer sixty years since describes Brunel's workshops at Battersea, where the single action of a steam-engine of sixteen-horse, or eighty-men power, turned by means of bands four wheels fringed with fine saws, two of eighteen feet in diameter, and two of nine feet. Here mahogany and rosewood were sawed into veneers the sixteenth of an inch thick; the same power at once turning these tremendous saws and drawing their work from them. A large sheet of veneer, nine or ten feet long by two feet broad, was thus separated in about ten minutes. The large saws revolved sixty-five times in a minute; hence, $18 \times 3{\cdot}14 \times 65$ gives 3,672 feet, or two-thirds of a mile, in a minute; whereas, if a sawyer gives thirty strokes of three feet in a minute, it is but ninety feet, or only the fortieth part of the steady force of Brunel's saw.

Brunel next invented a machine for making seamless shoes for the army, which, in regard to subdivision of labour, resembled the manufacture of pins. Every step was effected by machinery; while, as each operation was performed by one hand, so each shoe passed through twenty-five hands, who completed from the hides as supplied by the currier a hundred pairs of well-finished shoes per day. As each man performed but one step in the process, which implied no knowledge of what was done by those who went before or followed him, so the persons employed were not shoemakers, but wounded soldiers, who were able to learn their respective duties in a few hours.

SHIP-BUILDING.—XIV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS (*concluded*).

THE durability of an iron ship is practically governed by that of the outside plating, which is the part of the structure most liable to deterioration from the oxidising or corrosive action of the sea-water outside, and of the bilge-water within the ship. It will be understood that in making this statement we exclude the wood-work of the decks, inside planking, etc., which may be worn out and replaced many times during the period of service for which the iron hull remains efficient, and no argument will be needed to show the importance of using every possible means to prevent diminution in the thickness of the skin-plates.

The anti-corrosive paint most commonly used on the outer surface of the plates is red-lead, and this is found to answer fairly when renewed at frequent intervals. Other paints and compositions are also employed, most of which are patented; but it is doubtful whether any of them will ever entirely take the place of the cheap red-lead paint. This is also largely used for the protection of the inside of the plating from the

upper part of the bilges to the top-sides, where the wash of the bilge-water is not likely to reach when the ship is rolling at sea. Within these limits further protection is required, and is supplied by a thick coating of cement or asphalte, fixed upon the plating, cement being preferred in most cases. Experience has shown that the corrosive action of the bilge-water—arising from the substances it holds in solution, which render it an active chemical agent, or from other causes, such as galvanic action—is most to be dreaded; and many instances might be referred to in which the rivet-heads and the inner surfaces of the plating have been rapidly corroded when left uncovered. Lloyd's rules require all iron merchant ships to be protected below the bilges by cement or asphalte; and they also point out the desirability of so arranging the protecting material as to facilitate the drainage of the bilge-water to the suction-pipes of the pumps. The latter is an important practical matter, as the lodgment of bilge-water in any part of the vessel should always be prevented. To allow the bilge-water to flow readily to the pumps, holes or "water-courses" are cut in the transverse framing, longitudinals, keelsons, etc., and the cement or asphalte is brought just up to the height of these holes. By these means, when well applied, the corrosion and wasting of the plates are practically prevented, cases being on record where the reduction in thickness has not exceeded one-sixteenth of an inch in fifteen or twenty years.

Fouling cannot be so well prevented as corrosion, although very many schemes for its prevention have been proposed and tried. To give some idea of the number of such schemes, it may be stated that between 1861 and 1866 over a hundred patents for anti-fouling compositions were taken out, and during the same interval other compositions were proposed, the preparation of which was kept secret. At present, after all these attempts, the only means of keeping iron ships thoroughly clean is to dock them frequently, to clean or scrape off the growth of marine plants and animals, and to re-coat the bottom with some composition. Fast merchant steamers, such as those of the Peninsular and Oriental Company, are docked and cleaned about once in every six months, in order that no considerable loss of speed may be caused by foulness. Ordinary merchant ships are docked and cleaned about once per annum, the bottoms being coated with red-lead and some protective composition. In the Royal Navy it is customary to dock iron-built ships at least once a year, and to re-coat the bottoms; but the troop-ships employed on active service are docked more frequently. By this means any serious loss of speed can be prevented, when the necessary accommodation is available; but docks are not to be found in all ports to which merchant-ships proceed, or they may not be of sufficient size to receive the ships. And even when this difficulty does not occur, there is the question of expense to be considered, one which is of no small importance. For example, on the Thames the cost of docking, cleaning, and re-coating an iron ship of 1,000 tons gross register tonnage would probably be from £60 to £80, and for larger vessels the expense would, of course, be greater. In distant foreign ports the charges would necessarily be higher; and it might so happen that the vessel had been so long afloat as to render docking a necessity even under these circumstances. But experience proves that the truest economy is to be found in incurring the expense of cleaning an iron ship's bottom, rather than in allowing it to remain foul, and so greatly reduce the speed. There are instances on record in which vessels have been so retarded by foulness as to lose one-third, or even one-half their speed as compared with their performances with clean bottoms; and on a voyage like that from China or Australia, such a loss would far more than counterbalance the expense of docking and cleaning, considerable though it be. One indirect result of this fact is found in the rapid increase in docking accommodation all over the world since iron ships have been in use. Graving or dry docks, floating docks, hydraulic lifts, hauling-up slips, and other plans, have been devised for affording the accommodation required, and there is now consequently a greater chance of preventing iron ships from becoming seriously foul even on distant voyages.

Repeated trials of anti-fouling compositions show that the best of them cannot be considered efficient after more than an average of nine or twelve months' service. These compositions, it should be noticed, are distinct from the anti-corrosive preparations previously referred to, and are put on upon the latter. In the merchant service red-lead is, as we have said, the anti-corrosive paint most generally employed, and it answers very well. In the Royal Navy, either this, or else Hay's anti-corrosive composition, is generally used beneath the anti-fouling preparations. To name the latter would be tedious; to attempt to describe them would be a most hopeless task. Some inventors have based their schemes upon the belief that the barnacles, and other marine animals which attach themselves to the bottoms, should be poisoned by the anti-fouling compositions; but these plans scarcely appear well-founded, seeing that such animals are said to suffer no inconvenience when subjected to the action of the most deadly poisons. Other inventors, deeply impressed with the advantages of copper sheathing as used on wood ships, have attempted to prevent fouling by using preparations containing copper in some form; but here again failure has taken place as regards the prevention of fouling, and the iron hull has sometimes suffered corrosion in consequence of galvanic action resulting from the use of the copper. Another class of proposals consists in the attachment of cement, or glass, or some other material not likely to have any injurious effect upon the iron, to the outer surface of the plating; but these plans have also been found wanting when tried. In short, without saying more respecting the characters of the proposed anti-fouling compositions, it may be stated broadly that up to the present time no sufficient remedy has been found for this serious fault of iron ships. Whether a completely successful anti-fouling preparation will yet be produced it is impossible to say; but if it should so happen, the inventor will undoubtedly confer a great benefit, and should reap a rich reward.

A few remarks respecting the inside planking or plating wrought upon the frames of iron ships must conclude this paper. The general term "ceiling" is applied to all the internal planking, which is commonly connected either to the reversed angle-irons by nut-and-screw bolts, or nailed to pieces of wood (termed "cants") secured to the sides of the frame angle-irons. Between decks in many, but not all cases, the ceiling planks are worked with close-joints, and so form an inner lining. In merchant ships it is also common to have the floors up to the height of the upper part of the bilges completely lined, or "ceiled" over. From this height upwards in the hold-space, the ceiling is sometimes close, and at others only partial, the latter arrangement being known as "batten-and-space" ceiling. Half-round bars of iron are sometimes employed instead of wood planks when the batten-and-space plan is followed. In all these arrangements, however, the main object is to form an inner skin of some kind in the hold, upon which the "dunnage" or the cargo may rest, and to lessen the probability of damage to the skin-plating. There is no idea of adding structural strength, nor is such an addition at all necessary in a well-built ship. One prime consideration to be borne in mind in fitting the ceiling is the provision of means for readily removing the planks in order to ascertain the condition of the skin-plates, and to renew the protecting materials upon them when necessary. Over the parts where the cement is fitted such inspection is especially required; and it is a common practice to fit the ceiling upon the floors of merchant ships in detached pieces, or "hatches" that can be readily lifted. But in other places facilities should be provided for making an inspection of the condition of the hull; and in arranging the structure of an iron ship an endeavour should be made to render access easy to every part, for the purpose of inspecting, cleaning, and painting.

It is only proper to note in passing how great a contrast exists between the facilities for thoroughly ascertaining the condition of an iron ship, and the opportunities afforded for surveying wood ships. When the ceiling is removed from an iron ship, and she is placed in a dry dock with a clear hold, both surfaces of the skin plates are fully exposed, and may be reached by the surveyor. If corrosion has taken place in the plates, or in the frames, it can be readily discovered; if it is at all considerable, the thickness of the worn parts can be at once ascertained by drilling; and in case of need those parts can be removed without much difficulty, and new plates or bars fitted. The heads and points of the rivets are also open to observation, and so the surveyor has complete means of ascertaining the condition of the various pieces and their fastenings. Turning to the wood ship, a very different state of things is met with. Supposing her to be docked, and to have her hold cleared, it is not

possible by the strictest examination of the inside and outside to obtain a complete knowledge of her real condition. To do this planks must be removed here and there; the planking and timbers must be "bored" in many places to ascertain whether the wood remains sound; fastenings must be driven out in different parts, as their condition cannot be predicated from the examination of the heads and points, because the middle parts of bolts often waste without any external sign of the decay; and many other devices must be had recourse to if the survey is made thorough. Should repairs become necessary they are often most difficult and expensive. A rotten timber, for instance, can only be replaced with considerable difficulty, and in doing the work it often happens that other defects not previously discovered come to light. In short, the actual state of the iron ship can be ascertained with much less trouble than that of the wood ship, and any repairs needed can be effected with greater ease. These are considerations which should have great weight in judging the relative merits of wood and iron ships, and they greatly influence the commercial success of the two classes of vessels.

Reference has already been made to the fact that many iron ships have inner water-tight skins, forming double bottoms which add both to their strength and safety. The plating of these inner skins is sometimes worked on the in-and-out plan (illustrated by *c*, Fig. 34, page 305), and at others is fitted flush upon the frames. Mr. Scott Russell has adopted the former method in the *Great Eastern*, and other vessels built on his longitudinal system; and an example of the latter will be found in the part section of an iron-clad ship shown by Fig. 23, page 224. When the plating is flush, short edge-strips are fitted between the continuous angle-irons, on the under-side of the plates, so that no liners are required. This method is found to answer very well in practice, and to make water-tight work. It need hardly be said that the butts of the plates in the inner skins are carefully shifted both with regard to each other, and with regard to the butts of the outside plating and longitudinal frames. Carelessness in this particular would obviously lead to a considerable loss of strength, as compared with that attained when proper precautions are taken. In the Government service the diagonal shift of butts (Fig. 36, page 305) is commonly used for the inner bottom, and both edges and butts are single-riveted. This mode of fastening has also been adopted for the inner skins of ships built by Mr. Scott Russell.

In order to make the double bottoms thoroughly efficient as a means of preventing serious damage when the outer plating is penetrated, it is desirable to subdivide the space by numerous water-tight partitions, and to supply water-tight tops. Both these necessities are met in the iron-clads, and have been previously illustrated. As a rule the double bottoms are made to extend up to a few feet above the water-line, and to end at a deck, but this is not always done.

Merchant ships are seldom built with double bottoms, but it is becoming very common to construct tanks for water-ballast in some part of such vessels, and thus what is virtually a "partial double bottom" is often formed. Various plans are followed in building these tanks, but the feature common to most of them is the provision of a water-tight inner skin worked either upon the floors themselves, or else upon longitudinal keelsons fitted upon the floors, this inner skin being by some means brought into water-tight connection with the outer plating of the bottom. With transverse framing it is not an easy matter to ensure this water-tight connection, and to obtain it the frames in wake of the tank are often cut off near the turn of the bilge in order to admit a longitudinal plate-frame which shall form the side boundary of the tank. This frame has angle-irons on both edges, and is riveted to both skins, the caulking of the two joints being readily performed. Another plan consists in scoring the inner skin out between the transverse frames near the bilges, and riveting its edge to the outside plating; but this involves considerable difficulty in securing water-tightness at the junctions of the inner plating and the frames. The economical value of water-ballast, however, is so great as to override these questions of practical difficulty and expense. Ships so built can, by the admission of water into the tanks when without cargo, be brought to the proper trim; and the water can be pumped out speedily when required. Time and money are thus saved to a very considerable extent, and it is no wonder that ship-builders provide this simple means of avoiding all necessity for using rubble-ballast, on the old plan. The use of water-ballast began, we believe, in the iron screw colliers trading from the Tyne, and it has already been the source of enormous savings. If ship-builders were, however, to push their reforms somewhat further, adopting improved methods of framing, and complete double bottoms, they might, without sacrificing any of these advantages, produce stronger and safer ships.

SANITARY ENGINEERING.—XXI.

HOUSE DRAINAGE.

Passing on from the subject of our last two papers, closets and traps—*i.e.*, the mechanical appliances for what we may call the internal sanitary engineering of a house as contrasted with the external—we now come to the provisions requisite for removing sewage and waste water of different descriptions in the most efficient manner; and here we have to deal with many incidental circumstances arising from locality, the facilities of the neighbourhood, and other different causes. The method of external drainage for a town house, which has nothing to deal with but its own water-supply and sewerage, and of a country mansion in a district where no general sewage system exists, must necessarily differ in detail, although some few broad general principles will apply in each case.

Thirty years ago no general system of drainage was in existence, and cesspools were in very constant and general use even in London, and to this day in many courts and back-ways they are still in existence, though when discovered by the sanitary inspectors they are speedily done away with, and the modern system of pipe-drainage compulsorily introduced, as required by the Sewers' Act. As a matter of antiquarian curiosity, it may be interesting to remark that in sinking for unusually deep foundations in the City and elsewhere, it sometimes happens that old cesspools are opened of which the lining or walls (steining is the technical name) was done with the horns of animals curiously bonded together, forming a receptacle for the solid soil, but allowing the liquid manure to soak and drain away into the surrounding ground; these are probably of very early date.

In the time of the Romans chalk was used for a similar purpose built up dry in irregular lumps, and within the last few years two cesspools were discovered in the excavation for the foundation of a new building on Ludgate Hill. The late practice was to use bricks laid dry without mortar in a similar way, and old disused cesspools of this class are often turning up. In all urban districts or metropolitan centres the cesspool system has long been abandoned, and the general system of sewage bears the burden of all inhabited houses within a given area; but in some suburban districts, and in all country situations where there is no adjacent river or brook to receive the sewage, or in point of fact to act as a sewer, the necessity of the case compels the adoption of the cesspool system, and of this, therefore, with the various modifications and the necessary hygienic details, we must give some account. To return, however, to our subject proper—the details of house drainage. Some years ago an idea was prevalent that pipes of three inches diameter of glazed stone-ware would be sufficient to convey the drainage of an ordinary dwelling-house; but experience has proved that, though theoretically large enough, the constant stoppages arising from adventitious causes—a rag, a piece of newspaper, a gradual accumulation of grease from kitchen waste—required such constant attention that these small sizes of pipes have been long ago abandoned, and we may state that the sizes now practically in use are six inches diameter for a small house, and nine or twelve inches for a large house or a mansion. Where there is a general system of sewerage, these pipes should be conducted to the common sewer in the street or road, as much fall as possible being obtained as is compatible with the level of the ground or the nature of the situation. Two inches in the length of ten feet may be taken as an absolute minimum, as in cases where this fall is not obtainable it is better to adopt some independent mechanical method of dealing with the sewage or drainage. As an instance of the way in which exceptional cases may arise, we may mention the case of the London and Westminster Bank in Lothbury. On making some recent addition to this building, owing to the exceptional nature of the ground, a bog situate on the exact line of the old Walbrook, it was necessary that the ground should

be excavated to a depth considerably below any of the adjacent sewers; there was no influx of drainage proper, but a considerable amount of subsoil water to be dealt with; a small well or sump was formed for its reception, and it is periodically removed by pumping into an adjoining sewer.

The glazed drain-pipes now universally in use are comparatively a modern invention. Into the detail of their manufacture we do not now propose to go, as that will form the subject of other series of papers in THE TECHNICAL EDUCATOR, but only to explain the precautions to be adopted in their use, and the various modifications of constructions of detail required for efficient house-drainage.

There are various descriptions of pipes manufactured from different materials in different districts, all equally efficient, but each possessing some peculiar characteristics. In Staffordshire they are burnt from a species of fire-clay, and are dark in colour, similar in material to what are called Staffordshire bricks; in London they are burnt from clay obtained from various parts of the country with a large admixture of broken pottery finely ground and sifted for the better kind of work; while in Kent, in the neighbourhood of Aylesford, the Gault clay is the principal ingredient, and a pipe of lightish colour and very tough consistency is the result. The same patterns, however, apply very much throughout, and it is with the detail of these that we have now to deal. When first introduced they were about 2 feet in length, the joint being made by a plain socket, as shown in the sketch above (Fig. 36).

It is evident that where long lengths of pipes are laid upon this system, the only method of opening them for examination was to break one or more of the pipes, and when the repair was made a patch with tiles and cement was the result, running risk first of leaking, and then of an obstruction of the inside of the pipe by the falling in of a portion of the material, or the running out of the cement while the joint was being made, which subsequently would harden into a permanent obstruction. To get over these difficulties various plans were introduced. Our next sketch shows a method in which the upper lip, as we may call it, of the socket is absent, which allows a single length to be removed and another dropped into its place: this presents some advantages (Fig. 37).

Fig. 36.

Fig. 45.

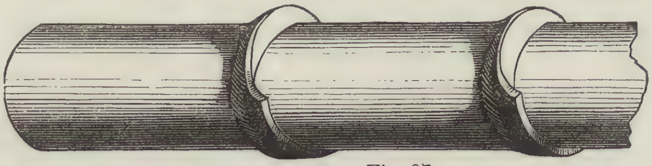


Fig. 37.

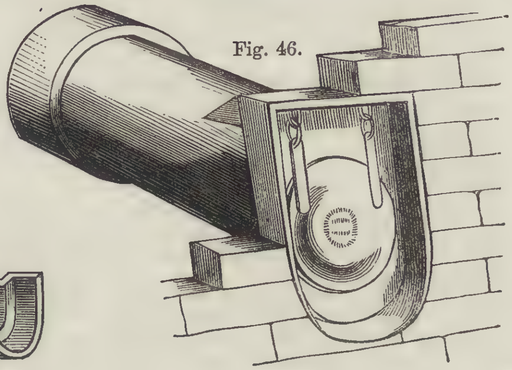


Fig. 46.

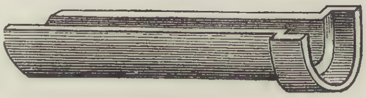


Fig. 38.

Fig. 44.

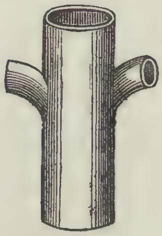


Fig. 43.

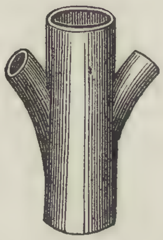


Fig. 42.

Fig. 40.

Fig. 41.

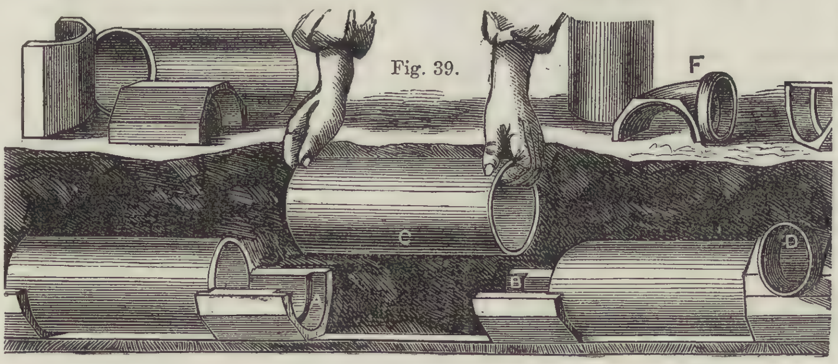


Fig. 39.

Another method is to manufacture the drain-pipe in two halves longitudinally, the upper half removable, the lower half remaining undisturbed while the drain is examined and cleared out. The sketch (Fig. 38) shows the construction.

Another more complicated but probably more efficient plan is shown below in Fig. 39, which also indicates the exact method of laying the pipes and the introduction of junctions.

There are various other inventions of similar character, but we have only instanced a sufficient number to show what facilities exist for ready access to a system of pipes for examination and cleaning.

In the erection of new buildings it is not desirable that the drain-pipes should be laid when the work is first commenced, for although the plan promises certain advantages in keeping the basements dry during the progress of the work, it is found in practice that the settlements which almost invariably take place in new work very often break the pipes where they pass through or under the walls; the subsidence or sinking of the ground from various causes sometimes produces the same result. It is therefore recommended that the carcase of the building should be first completed, and that the carrying out of the drainage should be deferred until the latest period at which it will not interfere with the floor-laying and finishing of the interior.

The junctions of pipes now claim our attention, and we give some illustrations of the "junctions," as they are called, which are made ready burnt for that purpose.

Figs. 40, 41 represent the junction *single* of a smaller pipe with a larger one at different angles, and we have to call attention to the point that the direction of the junction at its angle should always be the same as that of the fall or current of the

larger pipe, as if this is not attended to, and the entry is made in the contrary direction, obstruction will sooner or later result. We show in Figs. 42, 43, 44, 45 four different kinds of double junctions to which the same remarks apply. The ventilation of these drains is a very important matter now only beginning to occupy a leading share of public attention, as also the disinfection of the sewage gases arising in them; but with these points we shall deal at length in a subsequent paper. One point now remains to be alluded to—the entry of the drains into the sewer, where a sewer is in existence; this should always, if the level permits, be above what we may call the central axis, and for this reason, that if by accident the sewer should be flooded (and our late experience of metropolitan main drainage shows that even now such an event is far from uncommon, especially, as may we say, in the Farringdon Street district), all the lower end of the house-drain is filled by the back pressure of the water, and as long as the obstruction in the main-drain lasts becomes, as it has been called, an elongated cesspool; whereas if the entry is made well up towards the topmost level of the sewer, this difficulty is very materially obviated.

In many districts, metropolitan and otherwise, the sewers are waterlocked, as it is called, for twelve hours at least out of the twenty-four, and then some precaution like that indicated in Fig. 46 becomes most desirable—a stone-ware pipe provided at its junction to the sewer with a galvanised iron flap which closes as the tide rises. This is called a *tide-valve:* it opens the moment the tide falls at the slightest pressure of water from within; this prevents all back-water flowing up into the sewers or basement of the house, while it allows a facile exit for all the daily requirements at proper times of the tide.

Thus far we have dealt with the technical detail of "house drainage" in localities where a complete system of public sewers is in existence. We must now give some attention to localities where there is no such provision, and where, therefore, the introduction of a sump or cesspool becomes an absolute necessity; and here, taking the case of a large mansion or asylum situated in an isolated part of the country, we have various elements to consider. There is (1) the surface water; (2) the subsoil water; (3) the water-supply from well or otherwise; (4) the rainfall—various at different times of the year; (5) the sewage proper from closets, kitchens, stables, and elsewhere. The rain-water is sometimes separately dealt with and stored in a tank by itself. On sandy or gravelly soils not in a low district, the subsoil and surface-water may be left to take care of itself and make its way through the ground; but on heavy, low-lying clay lands this cannot be done, and therefore proper provision must be made for its disposal; and we may take this as a first axiom, that the cesspool, whatever its size—and for a large asylum it should be about as large as the dining-room—should be situated as far away from the inhabited portion of the buildings as possible, and should be made water-tight, providing at the same time ample means of ventilation from its upper levels; if this is not done, the sewage gases will find their way up the pipes, and, if these are not efficiently ventilated, into the living-rooms, with the certain result of general discomfort and unhealthiness, and in bad cases even of typhoid fever. If there is an available overflow, the waste sewage water may be advantageously distributed over the land; if not, mechanical means must be adopted to empty the receptacle at stated times.

In porous or open soils it may be advisable to have the pipes pervious, so as to allow the drainage water to percolate away through the surrounding land; and where, as in shingly soils adjoining the sea, the tide rises, no deleterious results will follow. But in retentive soils the result will be the saturation of the surrounding ground with sewage matter. In every case, however, local circumstances must dictate the course to be taken, and it is impossible to prescribe one uniform course for every locality.

Before the present generation these questions hardly arose, as the ordinary method of house-drainage was by the old-fashioned barrel-drain, as it was called, a simple tube of brickwork in mortar of various sizes from 9 inches upwards, built round a wooden centre which the workmen removed forward from length to length as the drain was built; while in some isolated districts common red pottery pipes were used mostly without sockets. In these cases the ventilation was provided for almost completely by the natural circumstances—the crevices existing in ordinary brickwork, and the butt-joints of the pipes, allowing a free escape for the sewer gases; while the larger size of the drains, never less than 9 inches for house purposes, left a very considerable air-space. Except, however, in cases of very rapid fall the amount of sewerage deposit in these old-fashioned drains was always considerable, and one important point to be attended to on entering upon a new property was to have the drains opened and cleaned out, a disagreeable and sometimes unhealthy process, which, however, it was absolutely necessary to repeat at intervals of a few years. Where a modern system of pipe-drainage is judiciously laid with proper points of access, the drains, if not entirely self-cleansing, as they may generally be made by the adoption of some of the systems of flushing described in our previous paper on "Economy of Water-supply," can be cleaned out and kept in a satisfactory state with comparatively little trouble or annoyance.

Since public attention has been so prominently directed to the subject, several new inventions have been introduced for the ventilation of house-drains, and of this subject we shall treat at some length in our next paper.

CAPITAL AND LABOUR.—I.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

THE SUBJECT IN GENERAL.

In the whole range of subjects with which political economy or social science has to deal, none is nearly so important as the relations which subsist between what are called capital and labour. At the present time the questions which arise on these relations are in the highest degree vast, difficult, and menacing. Attempts have been made from time to time to construct a society within society, in which an experiment can be made, for the purpose of substituting a new organisation for that with which we and our forefathers have been familiar since the earliest memories of civilised society. Such expedients, known by the general names of communism and socialism, have been advocated not only in France, Germany, and England, where the density of population, and the consequent pressure of poverty, lead to the ventilation of schemes for the reconstruction of society, but in the United States, where there is abundant space for all kinds of industry, and where, in consequence, those social problems which agitate an old and fully peopled country do not yet, and will not for a long time, be prominent enough to demand a solution.

Latterly, however, the movement has assumed proportions of far greater magnitude. Trade between nations, and the facilities of intercourse with which science has assisted trade, are making and will make the municipal boundaries which separate nations mere geographical expressions, which are easily passed. Modern communities are getting ideas from each other. A few years ago, the man who travelled over Europe was a mere exception. A few years ago the chief intercourse between nations were the diplomatic communications which governments instituted and maintained. Now the habit of travel is becoming general. It is rapidly influencing the artisan classes. Society, long immovable, is beginning to transfer itself from place to place. Nay, we are informed that labour has an organisation throughout the civilised world, which is rapidly being consolidated, which has its agents in every great town, and which, under the name of the International Society, is powerful already, and is likely to become more so. In all these attempts, partial and general, to change the foundations of society, there is a struggle between capital and labour, between profit and wages, between the employer and the workmen, between property and industry. I purpose in these papers to attempt an explanation of these several social forces.

Ask any economist, and he will tell you that capital is the accumulation of past labour, intended to move or assist labour, and that it is either a transient or a permanent assistance, the former requiring constant renovation, the latter being of an enduring character. Ask him what labour is, and he will tell you that it is the power which intelligence gives man over the properties of matter and life, by which muscular effort can make matter useful. It will be added that this power which the labourer is able to exercise over matter may be either the direct action of the man, or may be indirectly exhibited upon certain inorganic and organic powers; in other words, that the work-

man may be plying his own muscles, or may be guiding animal power, or be using steam, wind, or any other natural motion which man is able to control and direct for his own ends. In technical language economists speak of fixed and circulating capital, of muscular and nervous labour.

All these definitions and distinctions, however, are not fundamental, but only denote tendencies under which the same facts appear in different forms, or in which one of the circumstances which accompanies the fact is exhibited in different degrees of intensity. Thus the labour of a manager is said to be nervous, that of a workman muscular. But unintelligent effort is of no avail, even for the commonest acts, nor can the sharpest intelligence give effect to its thoughts, except by means of muscular effort. No labour appears to be more characteristic of the brain than the thoughts of a poet or musician are, but both these personages must at least exercise the mechanical function of writing or speaking.

Again, it is true that capital is the accumulation of past labour, embodied or condensed in material objects. With one exception—viz., land available for occupation or cultivation in densely-peopled countries—there is no object whatever, which possesses value, that has not obtained its value, by reason that labour has been expended on it. A sack of wheat, a bale of cotton, a barrel of wine, a wedge of gold, a house, a spinning-machine, possess whatever value the market assigns to them by reason that labour has been expended on their production. It signifies nothing, from this point of view, whether the article is movable or has been gifted with qualities which cannot be recovered or resumed in their original form. In every case, it is labour, and labour only, which confers on these objects those properties which economists recognise and comment on.

Unless we acknowledge this fact, we shall find it impossible to discern satisfactorily what are the relations of capital and labour, of the employer and the workman. If we acknowledge them, we shall, though not without some trouble, discover the key to these social questions, which, as I have already stated, are of such pressing and universal interest. For we shall discern that the production of labour is just as much an investment of labour, and therefore just as much an exhibition of capital, as any of these objects are to which reference has been made above. A man who brings up children, and renders them fit for those various forms of industry to which human capacity is fitted, is just as fully investing capital in them, as if he were building houses, or constructing machines, or collecting agricultural crops. It is only because his domestic relations to such children are the prominent features in their connection with him, that the position in which the education of labour stands to the general energies of society is misapprehended or ignored.

If we would see what is the significance of this production of labour to the general well-being of society, and observe how exactly it corresponds to any other investment of capital, we may consider an hypothesis, which could not happily become an actual fact, but may be contemplated as an abstract possibility, and has been, unfortunately, verified at one epoch in the history of civilisation. We can imagine that the transmission of that which an existing generation knows may be withheld from a growing generation, that the additions which are being made to the present stock of human knowledge or skill were arrested, and that what is known is not communicated. Such a state of things, it may be imagined, could occur suddenly. It has, as I have said, occurred gradually at one period in the history of mankind, for Europe in the tenth century of our era had lost nearly all the arts, and almost entirely the culture, which existed at the commencement of that era. The consequence of such a sudden cessation in the function of communicating the knowledge and skill of one generation to its successor, would be a rapid or gradual relapse into barbarism. Such a reverse would be of incomparably greater significance than any diminution in any other kind of wealth, and would be followed by infinitely more disastrous results. The maintenance and education of children is therefore a far more important investment of capital, a far more significant object of labour, than any other accumulation. It seems not to be so, only because under certain circumstances there are more men to work than there is work for them to do. To some extent this occurs in the case of other accumulations; for there may be more wealth accumulated than there are objects on which such accumulation can be advantageously employed. Quantities, however, of unemployed labour diminish the portion of general wealth which labourers can individually appropriate; quantities of unemployed wealth in other objects increase the power by which labour can be called into activity.

Capital, then, and labour available for industrial objects, and which is also in demand for industrial agencies, are only two forms of the same fact; both are accumulations of labour. There is no labourer who does not possess in himself an investment of capital; there is no capitalist who does not represent an active industry, if he be an employer of labour, and superintends the labour which he employs. The struggle which arises from time to time between the employer and the labourer, is a struggle between two forms of the same fact, between two forms of labour, each of which is seeking to appropriate more of that common produce which is shared between the labourers on the one hand and the employers on the other. In social science there is no struggle between diverse forces, rivalry existing only in similar forces. Hence if the function performed by the capitalist and that fulfilled by the labourer are united in the same person, not only is the quarrel necessarily at an end, but the maximum of productiveness is attainable at the minimum of cost or loss. In the course of these papers we shall see what are the phenomena of that state in which this harmony is effected. Until it is effected there is no means by which an adjudication can be made on these rival interests, except it be that of the barbarous expedient of strike and lock-out, or the temporary settlement of arbitration.

POSITION OF THE QUESTION IN ENGLAND.

In foreign countries, especially in France and Germany, the relations of labour and capital have been debated from that point of view which contemplates the reconstruction of society. These two countries have been the homes of those socialist or communist movements which aim at altering human life and action from its very foundations. These projects are futile, for civilisation, imperfectly as it may have been realised, is a true growth which cannot be made different from what it has become by means of any external influence. It is true that the advocacy of these expedients has made men restless, discontented, turbulent, and sometimes violent, but no success has ever followed on the efforts which have been made after such fundamental changes.

There is a reason, however, why these projects have been developed in these countries. In both the unity of the nation has been effected only after great toil, and by a government which has been almost despotic. Now, in such a state of society, the right of individual action or of combination is very sparingly accorded. The policy of a government in such a country tends always towards doing as much as it can, and of discouraging independent action on the part of its subjects. The administration is centralised, as people say. Hence the people learn to depend on government to give them a start, and refer to government when they are at a loss or in a difficulty. Now it is only a step from this state of mind to that other in which government does not merely regulate action, but takes upon itself the business of originating action. Under these circumstances a people begins to believe that government is a power which can and ought to confer great benefits on the people, which can assist them in a thousand ways, which can finally not only correct what is wrong in the laws or customs of society, but can do what is expedient, right, and charitable. But if the government can do so much good, why not, it is argued, undertake the development of that benevolent scheme which, in the dreams of some enthusiast, will remove all that is evil from the world, and produce all the good? Human life is full of misery and poverty: it is the business of those who govern human affairs to find a remedy for these disorders.

PRACTICAL APPLICATION OF THE FINE ARTS.—XII.

THE ART OF MOSAIC (*continued*).

By P. H. Delamotte, Professor of Drawing, King's College, London.

We give in the present paper some representations of mosaics, that have been, or are being executed by Simpson and Son of London. We had hoped to give these in colours, but as this

could not be accomplished, we must do the best we can with the woodcuts. In speaking of woodcuts, however, we may here remark, that in many of those given in previous numbers, among which we may reckon all those from Cirencester, the exact number and shape of the tesseræ have been preserved, the original pavements having been traced, and the tracing diminished by photography to the required size of the woodcut. But in spite of this, coloured illustrations would give far more clearly the style of work produced by English workmen in the present day.

We may be permitted to refer here to a life-size mosaic of Hogarth, intended for the South Kensington Museum. The likeness is naturally taken from the well-known portraits of the great father of the essentially English school of painting. We are glad, independently of the value of the mosaic, thus to point out a portrait of a man to whom English art owes so much. We look upon it that to Hogarth, even if he was not a painter of the highest class, nor a man of transcendent talent, English art, and so the whole range of national art, owes a deep debt of gratitude. By his determined protest against the trammels of foreign taste; by the violation, on the part of a man who had genuine thought and true enthusiasm in him, of the rules laid down for other times and other countries, he showed that each nation has peculiarities of taste and disposition that develop themselves in the arts of that country, if they are allowed legitimate play; that the artistic taste and feeling of one race cannot be violently transported into another; that the attempt to do this merely produces a race of copyists, with all the vices and the weaknesses of copyists; whilst each nation can alone develop and enlarge its own characteristic art, grafting in, it may be, from time to time some of the excellences perceivable in the arts of other races, but in the main keeping to the old lines. These remarks we do not confine to any one branch of that circle of human endeavours which we entitle fine art; but if it is, as we contend, entirely true of some, it must be true of all, and it will be impossible for some of the arts to rise from their present degraded condition in England until this position is truly recognised; and that as the politics of to-day take their root in, and form part of the whole history of this country, as far back as the mind of man can trace, so the arts of England must trace back their origin to the early and rude attempts of our ancestors, must develop the lines that these suggest, and add thereto whatever grace and beauty can be acquired first from nations kindred in blood and in taste, and next from the universal canon of taste which appeals to our common humanity. A wise artist is like unto a man that is a householder, who bringeth forth out of his treasures things new and old.

Fig. 30.—MOSAIC REPRESENTING ONE OF THE SEASONS.

But to return to the mosaic of Hogarth. The attitude is one of comparative repose, and thus fulfils the conditions we indicated when in a former number we recommended the study of the figures at Ravenna. The characteristics of the man himself, as he himself introduced them, his palette, the comic mask, and his dog, find natural places. The position is easy, and is that of a man contemplating his subject preparatory to active work which he may momentarily begin. This combined effect of a position that we are not surprised to see continued, and at the same time naturally leads to active motion, is highly suited for this material. It should partake somewhat of the calm character of sculpture, and yet the gold background so entirely throws the figure into relief, that we should almost anticipate motion.

The style of colouring is well adapted also to the material. We are not now dealing with the glass mosaic of Venice, for which Messrs. Salviati and Co. are so celebrated; nor with the Comati work from the Pope's workshop in Rome, in which various materials are employed; nor the *opus vermiculatum*, of which Florentine work is the modern representation; but with purely English terra-cotta work which has even been called *opus Anglicanum*. The materials employed are tesseræ of various shapes, principally small cubes and prisms of terra-cotta powder compressed, much as powdered black lead is squeezed in a vacuum until it acquires the hardness required for various kinds of pencils, so that it becomes much more compact and hard than by the ordinary mode of baking, and is capable of receiving a burnished surface. This terra-cotta material, however, naturally does not produce the brilliant colours nor the bright effects of glass; it would consequently be absurd to attempt the same style of colouring as may suit an Italian sky and a vitreous material. And this is a great advantage, especially since other causes have contributed so much towards fostering a taste for a heavy, crude, and over-loaded tone of colouring both in our pictures and our manufactures. Rather dull colours harmoniously disposed, therefore, are suitable to most subjects, and contrast all the more vividly with the bright

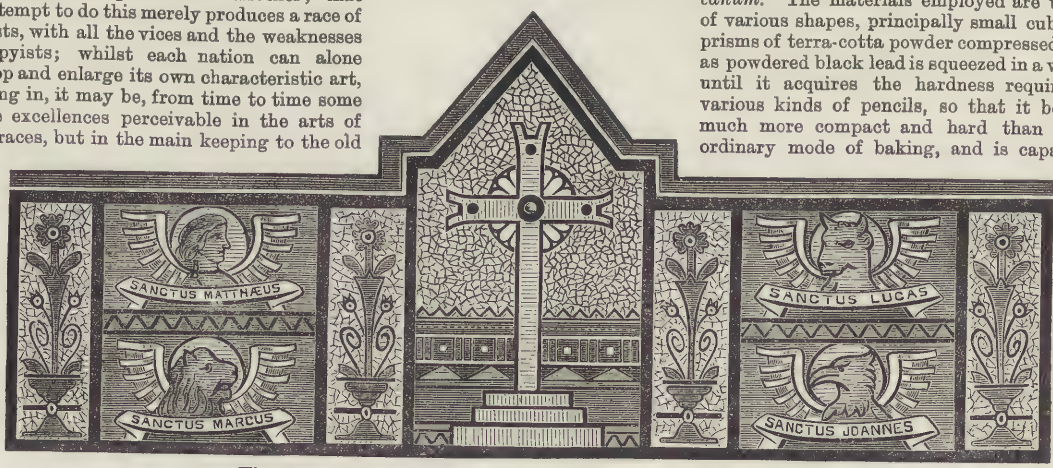


Fig. 32.—DESIGN FOR A PORTION OF A REREDOS IN MOSAIC.

and flat, yet varied, golden background. The necessity for making the terra-cotta tesseræ in moulds, confines the shapes to only a few varieties of surface—squares, rectangles, and triangles of various forms complete the category. It is impossible, therefore, to produce the irregularity either of the old Roman pavements or of modern glass mosaic. This has its advantages and its disadvantages. Among the latter may be esteemed a certain flatness originating from the formality of shape, and the non-appearance of the cement between the interstices of tesseræ, though in this respect the modern glass mosaicists also lose a strong element of beauty, and throw away one of their advantages, by using cement coloured to match their materials. But as a compensating advantage the terra-cotta worker has a wider range of shades, since the blocks being far smaller than the *smalti* are ever broken into, the gradations of colour and shade are better preserved. In order, too, to counteract the flatness of the regular divisions, the English workman breaks up his gold, which, of course, consists of *smalti*, into irregular portions, thus causing a very different effect from the more regularly divided gold backgrounds of the Italians.

In such pieces of workmanship as the portrait of Hogarth, there are, of course, a great many degrees of difficulty and of excellence in the mere work. The flat backgrounds require but little skill to match the pieces to the most convenient forms. The outlines of clothes, the matching of tints, and the drawing of the coarser parts require more delicacy and taste, whilst the hands and heads demand the skill of a regularly trained artistic workman. A very large proportion of the work done at South Kensington and at other manufactories of mosaic is executed by women, and this is a branch of labour well suited to their capacities, since it is rather neatness and taste than bodily strength that is required.

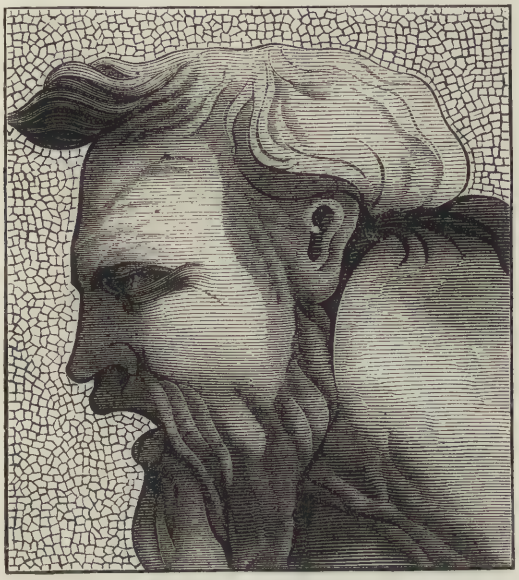


Fig. 31.—HEAD OF THE PROPHET ISAIAH, DESIGNED FOR ST. PAUL'S CATHEDRAL.

We give in the preceding page (Fig. 30) a medallion, one of four on a screen, intended to represent the seasons, a subject common enough amongst the ancients, as we have noticed before. In this case, though only three colours are used, several tints are required to produce the shadows, and to throw up the forms. Fig. 31 is intended for a head of the prophet Isaiah, and is taken from a design by Mr. Alfred Stevens for a pendentive in St. Paul's Cathedral. It is well that the cathedral church in the metropolis should receive the best we can give it in the form of an offering from Art; and it is to be hoped that the effort now being made to decorate the interior in a manner worthy of the original design may be as successful as it deserves to be. The completion of a great work like this must lead to a more elevated taste amongst the many who day by day have this object presented to their view. Recent improvements in London have led to many openings through which the great cathedral can assume its proper proportions; and it would be sad that after the mind had been prepared by these distant views, and by a closer admiration of the colossal size of the structure, that all enthusiasm should be baulked by a bald and cold interior. We hope, therefore, that something may be done worthy of the great building itself; worthy of the city over which it presides; and worthy of the nation of which it is, from a civil if not from an ecclesiastical point of view, the principal church. The design before us is worthy of such a building. Bold and massive in its treatment, it is suitable for contemplation at a distance: we may, therefore, be sure that it will be worked out in a forcible manner, with tesseræ of considerable size, and shades plainly delineated. We trust to such work as this to elevate both artist and workman, and to prepare the way for further advances on the same road.

Fig. 32 is intended to represent a portion of a reredos for a parish church. The ordinary emblems of the Evangelists have their names beneath them. These stand out from a dull background; but in a still more striking manner does the central emblem of the cross in pure white arise from a background of gold. The intervening spaces are filled with conventionalised flowers. The effect of good mosaic with a large admixture of gold in it in lighting up and enlivening our churches, generally either devoid of colour, or else relying on paint and hangings for the tone that should be obtained from the structural materials, ought to be studied by all those who are anxious to help on the progress that architecture has been making for many years, and which we hope it will long continue to make. As we said at first, mosaic is an architectural art, and unless it subserves the main purposes of a building, it is not likely to gain a permanent hold on the taste and feelings of the nation. We hope to see the day when amongst the English who are true lovers of the real, the solid, and the permanent, mosaic may find a place as much its due, and as consonant with our feelings, as it was with those of the Romans of old, when a man of taste and property felt that his house was not properly finished, nor his furniture fitly decorated, unless they were alike adorned with mosaics of the highest order of merit.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIV.

BY E. WYNDHAM TARN, M.A.

SMITH'S WORK AND BELL HANGING.

THE smith's work in a building includes all heavy materials of cast or wrought iron, as furnace and chimney bars, girders, columns, iron joists, heads to king and queen posts, tie-rods and bolts, newels, brackets, cantalivers, rain-water pipes and gutters, iron railings, guard bars, cramps, cisterns, tanks, furnace and soot doors, grates, stoves, ranges, stable fittings, iron roofs, etc. Most of the smith's work is taken by weight, even where it has to be measured, the sizes of the articles being entered in the dimension book, and afterwards brought into lbs., cwts., or tons by means of a table of the weight of iron of given breadth and thickness. Articles in cast iron that require a pattern to be made expressly for them must be taken by weight, and the patterns numbered separately; but for articles in common use, or where a large number of the same pattern is required, the pattern is not charged. All labour in filing and fitting cast-iron work must be taken by the foot-run. Measure the length of cast-iron columns or cylinders, and enter it in the dimension book, stating the diameter externally, and also internally if hollow; the weight per foot-run can then be ascertained by help of the following

TABLE OF WEIGHT OF SOLID ROUND CAST-IRON COLUMNS PER FOOT-RUN.

DIAM.	WT.	DIAM.	WT.	DIAM.	WT.	DIAM.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
1	2½	2½	15⅓	4	39¼	5½	74¼
1½	5½	3	22	4½	49⅔	6	88⅓
2	9¾	3½	30	5	61⅓	7	120¼

To find the weight of a hollow column or cylinder by means of this table, deduct the weight of a solid column having the given internal diameter from that of a column having the given

external diameter. Thus the weight per foot of a hollow column 6 inches outside diameter, and 5 inches inside, or with $\frac{1}{2}$-inch metal, is $88\frac{1}{3}$ less $61\frac{1}{3}$, or 27 lb.

The weight of cast-iron girders may be found by taking each part separately—namely, the top and bottom flanges and the web, giving the width and thickness of each, and finding their weight from the following

TABLE OF WEIGHT OF FLAT CAST IRON, 1 INCH WIDE, PER FOOT-RUN.

THICKNSS.	WT.	THICKNSS.	WT.	THICKNSS.	WT.	THICKNSS.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
$\frac{1}{4}$	$\frac{4}{5}$	1	$3\frac{1}{8}$	2	$6\frac{1}{4}$	$3\frac{1}{2}$	11
$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$3\frac{7}{8}$	$2\frac{1}{2}$	$7\frac{3}{4}$	4	$12\frac{1}{2}$
$\frac{3}{4}$	$2\frac{1}{3}$	$1\frac{1}{2}$	$4\frac{3}{4}$	3	$9\frac{1}{3}$	5	$15\frac{2}{3}$

For example, to find the weight per foot-run of a cast-iron girder with parallel flanges, the flanges being $10'' \times 2''$ and $3'' \times 1\frac{1}{2}''$, and the web $12'' \times 1\frac{1}{4}''$; $10'' \times 2''$ weighs $10 \times 6\frac{1}{4}$, or $62\frac{1}{2}$ lb.; $3'' \times 1\frac{1}{2}''$ weighs $3 \times 4\frac{3}{4}$, or $14\frac{1}{4}$ lb.; $12'' \times 1\frac{1}{4}''$ weighs $12 \times 3\frac{7}{8}$, or $46\frac{1}{2}$ lb.; and by adding these weights together, we find that of the girder to be $62\frac{1}{2} + 14\frac{1}{4} + 46\frac{1}{2} = 123\frac{1}{4}$ lb. per lineal foot.

The weight of cast-iron stanchions, storey-posts, etc., can be also found by help of this table. The weight of flat plates of cast iron can be found by means of the following

TABLE OF WEIGHT OF FLAT CAST-IRON PLATES PER FOOT SUPERFICIAL.

THICKNESS.	$\frac{1}{8}''$	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	$4\frac{2}{3}$	$9\frac{1}{3}$	14	$18\frac{3}{4}$	$23\frac{1}{2}$	$28\frac{1}{8}$	$32\frac{7}{8}$	$37\frac{1}{2}$

Cast-iron rain-water pipes, and eaves gutters are taken by the yard-run, every fraction of a yard being taken as a full yard; the heads, shoes, nozzles, angles, sockets, bends, T and L pieces, etc., are numbered. The size and pattern of the gutters and pipes must be described, and whether galvanised. Cast-iron balconies, and other railings, are often taken by the foot-run, describing the height and character of design. Cast-iron copings are taken by the foot-run; coal-plates, scrapers, bell-traps, pumps, etc., are numbered according to size. Stoves for open fireplaces are valued at per inch width of frontage, and according to quality; it is common, however, to state the value per stove. Ranges and kitcheners are also valued according to the width of opening, and numbered in the bill. Cast-iron frames and doors for furnaces are taken by the pound weight.

The iron ramps, sills, posts, mangers, troughs, etc., for stable fittings are generally numbered; the cast-iron channel guttering being taken by the foot-run. Cast-iron gratings are taken by weight, which can be determined by the foregoing tables; small gratings, as air-bricks, etc., are generally numbered.

Wrought iron, when used in large quantities or dimensions, is taken by weight, the length being entered in the dimension book, describing diameter, width, or thickness, as the case may be. The weight per foot-run of round wrought iron can be found by the following

TABLE OF WEIGHT OF ROUND WROUGHT IRON PER FOOT-RUN.

DIAM.	WT.	DIAM.	WT.	DIAM.	WT.	DIAM.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
$\frac{1}{4}$	$\frac{1}{5}$	1	$3\frac{1}{3}$	2	$13\frac{1}{2}$	$3\frac{1}{2}$	$41\frac{1}{6}$
$\frac{1}{2}$	$\frac{7}{8}$	$1\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{1}{2}$	21	4	$53\frac{3}{4}$
$\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{1}{2}$	$7\frac{1}{2}$	3	$30\frac{1}{4}$	5	84

The weight of wrought-iron girders, joists, flat bars, etc., can be found by taking separately the different thicknesses, the weight of which per foot-run is given by the following

TABLE OF WEIGHT OF FLAT WROUGHT IRON, 1 INCH WIDE, PER FOOT-RUN.

THICKNESS.	WT.	THICKNESS.	WT.	THICKNESS.	WT.	THICKNESS.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
$\frac{1}{8}$	$\frac{2}{5}$	$\frac{3}{4}$	$2\frac{1}{2}$	2	$6\frac{3}{4}$	$3\frac{1}{2}$	$11\frac{3}{4}$
$\frac{1}{4}$	$\frac{7}{8}$	1	$3\frac{1}{3}$	$2\frac{1}{2}$	$8\frac{1}{2}$	4	$13\frac{1}{2}$
$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	5	3	$10\frac{1}{12}$	5	17

The weight of flat plates of wrought iron of various thicknesses can be found by means of the following

TABLE OF WEIGHT OF FLAT WROUGHT-IRON PLATES, PER FOOT SUPERFICIAL.

THICKNESS.	$\frac{1}{8}''$	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	5	10	$15\frac{1}{8}$	$20\frac{1}{6}$	$25\frac{1}{5}$	$30\frac{1}{4}$	$35\frac{1}{3}$	$40\frac{1}{3}$

The lengths of wrought-iron chimney bars are entered in the dimension book with their width and thickness. Iron hooping is taken by length, the width and gauge being described. Sheet iron, used as linings to the panels of doors or shutters, is measured by the superficial foot, and thickness described. Screw bolts, with nuts, plates, etc., are numbered, with a description of the diameter, length, etc.

Wrought-iron sashes, fanlights, skylights, casements, etc., are taken by the foot superficial; guard or saddle bars by weight. The lead used in running iron into stone is to be taken by weight.

Iron roofing is measured by the square of 100 feet, taken on the slope of the rafters; and corrugated iron roofs must have an allowance, in taking the dimensions, of one-fourth for the laps.

Wrought-iron doors and frames are taken by the foot superficial, except those for furnaces, which are usually taken by weight.

If iron is galvanised, the area of the surface must be measured for the value of the galvanising.

Iron set-pots and coppers are taken by weight, the labour of fixing being taken with the bricklayer's account.

When copper is used for the covering of roofs, flats, or gutters, measure it by the foot superficial, describing the number of ounces to the square foot.

To estimate the cost of bell-hanging in private houses, take the number of the bells, including with each bell the wire, cranks, tubing, springs, carriages, etc.; state at the same time whether they are hung in peals; pendulums, levers and other pulls are usually numbered separately. Large bells are taken by the pound weight, the hanging being valued separately. Electric bells are valued according to the number of pulls which are supplied, and the distance which the wires have to be conveyed.

We will now further elucidate the measurement of the smith's work by an example of entries in a dimension book:—

2)	10 6	21 0	C. i. holl. col., 6″ external and 5″ internal diamr.
2)	14 6	29 0	C. i. T girder, flanges 10″ × 2″ and 3″ × ½″, web 12″ × 1¼″.
	25 6	25 6	5″ O. G. gutters.
	28 6	28 6	6″ ½ round eaves, ditto.
	48 0	48 0	3″ R. W. P.

No. 2 heads. 2 shoes. 2 nozzles. 2 angles to O. G. gutter.

	10 6	10 6	C. i. balcony, 21″ high, with w. i. top rail and standards.
	25 0	25 0	Ditto coping to 9″ wall.

No. 2 c. i. coal plates with hooks.
„ 4 air-bricks.

	2 6 1 6	3 9	C. i. casement and frame.
6)	8 0	48 0	W. i. chimney bar, 2″ × ½″.
10)	6 6	65 0	1″ round w. i. guard bar.

5 lb. lead for running bars.

2)	5 6 1 3	13 9	½″ in. w. i. shelf.
	25 0	25 0	W. i. top-rail, $2\frac{1}{2}''\times\frac{1}{2}''$.
40)	3 3	130 0	1″ sqre. w. i. bars.

No. 40 pointed ends to bars.
,, 40 cutting holes for bars in rail.
10 lb. lead for running.
No. 1 w. i. frame and door to copper.

	6 0 2 6	15 0	½″ w. i. door and frame.
4)	2 0 1 3	10 0	⅛″ sheet-iron linings to panels.

No. 1, 4 ft. 6 in. kitchener.
,, 2, 3 ft. register stoves, polished steel front.
,, 4, 2 ft. 6 in. ditto, Berlin black.
,, 1, 20″ copper, 20 oz. to the foot.
Hanging 10 bells with copper wire, cranks, concealed tubing, springs, brass T-plate back carriage, pendulum, etc., complete.
No. 4 ornamental lever pulls.
,, 1 brass knob, pull, and plate. 1 brass slide pull.

ABSTRACT.

Cast Iron.		Wrought Iron.		BellHanger
Hol. columns, 6″ diamr. ½″ thk. ft. 21 0 27 567 lb. T girders. 29 0 123½ 3574½ 567 4141 36 cwt. 109 lb. Supl. Casemt. and frame. ft. 3 9	Run. 5″ O.G. gutter ft. 3)25 6 8½ yds. 6′ ½ round eaves gutter. ft. 3)28 6 9½ yds. 3″ R. W. P. ft. 3)48 0 16 yds. Balcony 21″ high, w. i. top rl. and standds. ft. 10 6 Coping on 9″ wall. ft. 25 0 Numbers. Heads and shoes to 3″ R. W. P. 2 Nozzles. 2 Angles to O.G. gutters. 2 Coal plate and hook. 2 Air-bricks. 4	Chimney bar, $2''\times\frac{1}{2}''$. ft. 48 0 3 144 lb. 1″ round guard bar. ft. 65 0 3⅓ 217 lb. ½″ shelf. ft. 13 9 10 137½ lb. Rail, $2\frac{1}{2}''\times\frac{1}{2}''$. ft. 25 0 3¾ 93¾ 1″ bars. ft. 130 0 3⅓ 433 lb. Lead for running. 5 10 15	Superf. ½″ door and frame. ft. 15 0 ⅛″ sheet iron linings to panels. ft. 10 0 Numbers. Points to 1″ bars. 40 Holes in ½″ rail. 40 Frame and door to copper. 1 4 ft. 6 in. kitchener. 1 Copper, wt. 14 lb. 1 3 ft. regr. stove, steel front. 2 2 ft. 6 in. ditto, Berlin black. 4	Hang. bells complete, cranks, tubing, spring, back carriage, pendulum, etc. 10 Ornl. lever pulls. 4 Brass knob, pull, and plate. 1 Brass slide pull. 1

TECHNICAL DRAWING.—LXXI.

DRAWING FOR BRICKLAYERS.

EXTERNAL OR CAMBER BRICK ARCHES, AS APPLIED TO DOORS AND WINDOWS.

OUTSIDE arches are of two kinds, straight and semi-circular, or segments of a circle. Straight arches are perfectly horizontal above, and have the same appearance below, and unless the drawing be very large they are so represented. They should not, however, be quite straight, but should always have a rise of about half an inch in three or four feet, so that their intrados is an arc of a circle, like that of a segment arch; but the joints always radiate to some point much nearer than the centre of the said arc.

The bricks used in arches always show their thickness or edge in the face of the wall, which thickness being from two and a quarter to two and three quarters at the utmost, this dimension is used at the top of the straight arch, or at the extrados of the curved one, and thence it diminishes, owing to the splay of the arch-bricks, to the soffit of the straight arch, or to the intrados of the curved one.

This splay is termed the *sommering* of an arch. The bricks used in external arches are always rubbed with great care to the proper splay or wedge-like form necessary, and according to the gauges or regularly measured dimensions. For this reason they are styled *gauged arches*, to distinguish them from inside or *rough arches*, in which common bricks are used without being rubbed or shaped in any way.

A drawing of a straight-arched window is given in page 263, Vol. I., of THE TECHNICAL EDUCATOR, and to this the student is referred.

It will be evident that in a straight arch no two voussoirs, or arch-bricks, as they may be termed, on the same side of the centre, or key of the arch, are alike; but those of the contrary sides will correspond with each other, pair by pair.

In semi-circular or segment arches, on the contrary, all the arch-bricks between every two of the adjacent radiating points are exactly alike.

The number of bricks in a semi-circular arch is determined by finding how many thicknesses of a common brick are required at the extrados or outside of the arch, and from the points of division drawing lines to the centre of the arch, which will determine the splay, and give the rule for rubbing the bricks to their proper form.

Semi-circular, or segmental arches, are commonly used over the recesses in which doors or windows are situated, and the aperture within is also usually arched over by a concentric arch of a smaller span. In such cases the upper or greater arch is usually made a brick and a half in thickness, but the lower, or smaller arch, within the recess is made only one brick thick, being equal to the face of the thin wall on each side of the aperture within the recess.

The exterior and interior elevations of a segmental window have been given in page 264, Vol. I., of THE TECHNICAL EDUCATOR.

The example given in Fig. 585 represents a semi-circular arch of four feet width and one brick in thickness at top. This is a portion of the elevation of one of the arches over several of the doors of the officers' quarters in the Ordnance Barracks at Chatham. These doorways are 7 feet 6 inches high from the upper step to the spring of the arch. They are situated within a recess, the outline of which only is given in the present figure, the upper or second arch being omitted for the sake of clearness.

Fig. 586 is the half elevation of one of the arches of the recesses about the same doorways, which are one brick and a half in thickness; the arch of the doorway itself, illustrated in the previous figure, appears only in outline in the present example.

It is to be observed that the length of ornamental arches of this description thrown over a recess, as measured from the face of the wall inwards in a barrack or dwelling-house, never exceeds half a brick, or about 4½ inches, unless the thickness of the wall should be greater, which is not usual.

In like manner the length of an ornamental arch above a door or window, whether situated within a recess or not, never measures more than half a brick, unless the reveal be thrown

further inwards, which is not usual in buildings of the above description.

Hence, such ornamental arches are mere shells, which support a portion of the wall towards the outside only. Accordingly if, as in the recessed doors alluded to in these barracks, there be a double semi-circular arch—namely, one over the recess and one over the door—these two between them support only eight or nine inches, or a thickness in the wall equal to about one brick, and therefore, of course, the rest of the thickness of the wall (which in the present instance is a two-brick thick wall) must be provided for in some other way. This is done by means of a rough brick arch on the inside, concentric with the two others, but of rather greater span than the smaller of the two, in order to allow for a "reveal" of the dimensions judged necessary.

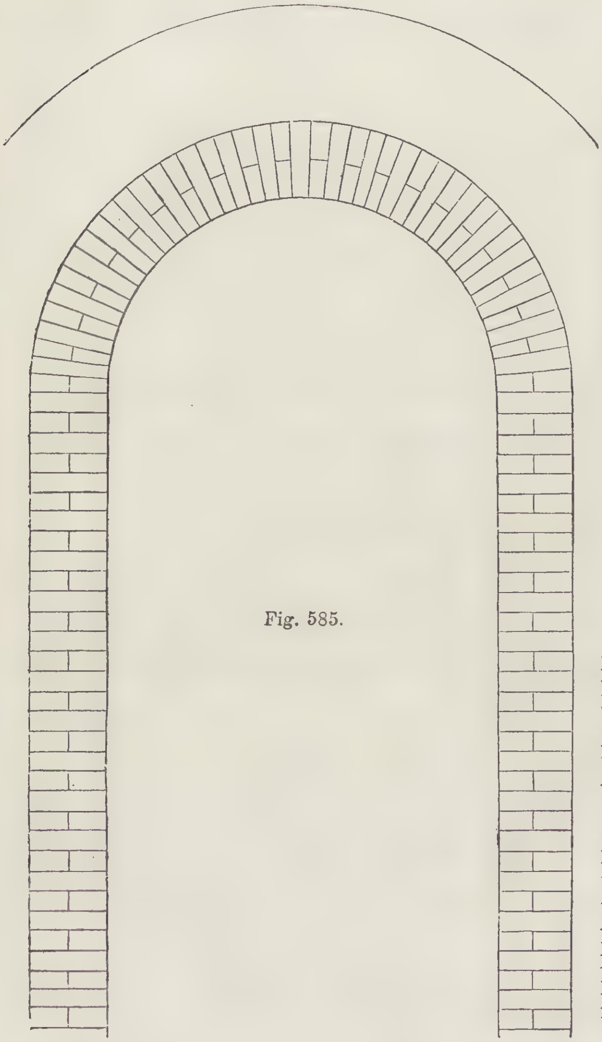


Fig. 585.

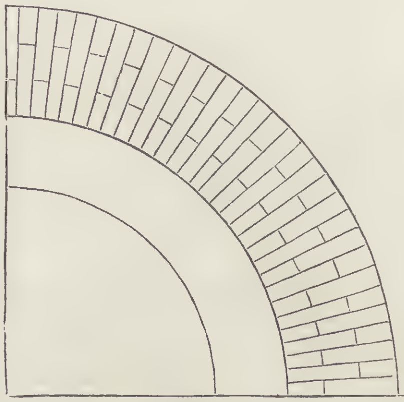


Fig. 586.

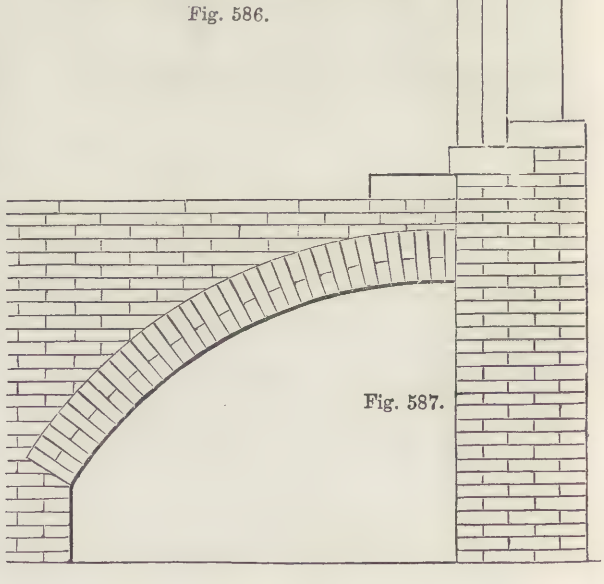


Fig. 587.

Fig. 587 is a section of one of these doorways, and represents this arrangement; *a* is the ornamental or external arch over the recess, which is a brick and a half high; *b* is the ornamental arch within the recess over the door, which is one brick thick. Each of these two arches is half a brick in length, measuring from the face of the wall inwards; *c* is the rough arch afterwards covered with plastering, which is one brick in height and one brick in length.

On examining this figure it will be seen that the two ornamental arches are by no means well connected. In fact, although each may support its own part of the superincumbent brickwork, there is no common bond between them. If, however, they be respectively executed with proper care, and in a workmanlike manner, and if the bricks and mortar or grout used be good, there is no risk of failure.

The execution of all the ornamental or thin arches in the face of a building, such as have been described, should be most carefully attended to whilst in progress. Bricklayers will always take sufficient pains to rub the outside of each arch-brick properly, so that their work may have a handsome appearance to the eye, but often slur over all the other parts of the work which are hidden from view. Hence, in order to save trouble, they are very apt to cut away the inside of the bricks of those arches to such a degree as may even deprive them of their proper wedge-like form everywhere except at the external surface. This neglect produces cracks, and causes the arch to bulge forward. It may even cause one of the bricks of a straight arch to drop down lower than the soffit or bottom of the arch, which defects may frequently be observed over the windows of common brick buildings.

In respect to ornamental arches of one brick in thickness and only half a brick in length, of which a specimen is given in Fig. 585, it is advisable that none but whole bricks should be used in constructing them, because the use of the two bats in every alternate voussoir, as appears in the figure alluded to, would in practice weaken the arch in some degree. But in this case false joints may be represented in every alternate voussoir, should it be thought that the mixture of small joints would better accord with the general effect of the other parts of the brickwork.

FARMING AND FARMING ECONOMY.—XIV.

By Professor Wrightson, Royal Agricultural College, Cirencester.

SHORT-HORNS.

INTRODUCTORY REMARKS—SKETCH OF HISTORY—PRINCIPLES INVOLVED IN BREEDING CATTLE—IN-AND-IN BREEDING—"POINTS" OF SHORT-HORNS.

We propose to devote a chapter to the study of short-horns. We do so because no race of cattle has had such a rapid rise, has been so "artificially" produced, has obtained such a wide-spread popularity, or possesses such a combination of those aptitudes for which cattle are prized. The skill of the breeder has been lavished upon it, and the material upon which such skill has been exerted has possessed the necessary plasticity to ensure success. Reference has already been made to the extraordinary prices recently paid for short-horns, and the records of public sales during the last year clearly indicate the high estimation in which these animals are held. We, however, fear that the exaggerated value now set upon pedigree is introducing an element of decay. Rigorous selection and a keen regard for personal merit especially require enforcing, and without undervaluing pedigree we think that it is too much relied upon at the present day as the test of value. Without further comment we propose to commence the consideration of this remarkable race of cattle with a short history of its rise and gradual diffusion over this country. We shall next devote a little time to the principles that guided its early promoters, and lastly, give the points looked for in first-rate examples of the breed.

The short-horn must be a familiar object to almost every one. Who has not admired the tranquil scene of cattle grazing or resting in rich meadows, or standing knee-deep in water, shaded from the sun by magnificent trees? Such pleasing additions to the landscape cannot fail to attract and charm the eye, and we accept them as the happiest manner of introducing our bovine friends. But are these short-horns? If, we answer, the herd consists of red and white horned cattle, in which the two colours named are pleasingly diversified, one animal being red, another white, a third red and white, while a fourth is probably a rich roan, we may generally assume that we are either looking at short-horns, or animals strongly impressed with short-horn character. Such cattle are now generally distributed throughout the United Kingdom; but within the last seventy years they were almost exclusively confined to the counties of Durham, Yorkshire, and Northumberland. To give more than the merest outline of the history of short-horn cattle would be impossible in a short article like the present; we must therefore deal with the subject generally, and at the same time with the utmost conciseness.

Robert Bakewell, of Dishley, Loughborough, Leicestershire (born 1726, died 1795), must be credited with having first turned the attention of agriculturists in the direction of improving their live stock. It was in his hands that the old English black horse, the Leicester sheep, and the famous long-horn or Leicester cattle, were brought to perfection; and there is no doubt that his example and precepts were followed by the brothers Colling, of Barmpton and Ketton, in their successful endeavours to improve Durham cattle. Long previous, however, to the time of the Collings, the Durham breed had been preserved with care. Thus pedigrees had been kept in some cases from the time of the cattle murrain, in 1745, and the Dukes of Northumberland, the St. Quintins, the Pennymans, Milbanks, and other county families, had long taken just pride in their cattle. It also appears that a Mr. Dobison, of The Isle, Sedgefield, used a Dutch bull with success, and other breeders followed his example with rather prejudicial effects. The improvement of the county cattle, thus commenced, received a wonderful impetus from the labours of Charles and Robert Colling, who, by collecting together the best females, and allying them to sires of unrivalled merit, succeeded in laying the foundation of a breed which has found admirers in every district of this country, and seems destined to extend over a large portion of the civilised world. In 1810 Mr. Charles Collings' short-horns were sold at Ketton by Mr. Kingston, auctioneer, at an average of £151 8s. over forty-seven head, and in 1818 Mr. Robert Collings' cattle were dispersed at Barmpton, realising an average of £128 14s. 9d., over sixty-one head, old and young. In the first-named sale the bull "Comet" was sold for a thousand guineas, and in both many animals realised two, three, and four hundred guineas. The purchasers of this celebrated stock in turn became noted as the possessors of pure blood, and further extended the breed. The Chilton cattle, under the fostering hand of Mr. Mason, had long been famous, and the sale of this herd in 1829, at which Lord Spencer was a principal buyer, may be looked upon as the next leading event in short-horn history. Mr. Whitaker, of Burley, held his sale soon after, and in the language of "The Druid," Sir Charles Knightley, of Fawsley, gradually became quite a Whitaker of the Midlands. Mr. Richard Booth, of Warlaby, Yorkshire, and Mr. Bates (afterwards of Kirklevington), on the banks of the Tyne, were contemporaneous with the Collings. Both purchased bulls at Barmpton and Ketton, and both became so famous as breeders of short-horns that we shall again have to

SHORT-HORNED COW.

a, Shoulder-top; b, crops; c, chine; d, hook, hip or pin bone; d', space; e, loins; f, ridge; g, beef-bed; h, set-on of tail; i, rump-bone; k, twist; l, buttock; m, flank; n, hock; o, udder; p, fore-udder; u, dew-lap; v, breast; w, shoulder-points; x, neck-vein.

notice their proceedings. Such were the most eminent early improvers of short-horn cattle. With good material to work upon, they brought out animals which probably have never been excelled, and from their time down to the present the successes of breeders have rather been in the direction of maintaining and diffusing than in improving their favourite breed. No greater monument of the care taken in maintaining the purity of the race can be shown than the Herd Book, now numbering nineteen volumes, and containing the pedigrees of some 30,000 bulls, as well as a corresponding number of cows. Such a work also clearly shows the impossibility of giving in a single chapter even a faint idea of the many well-known strains of blood, the rival merits of which are keenly discussed by "short-horn men." Leaving, then, such highly technical details, let us turn to the consideration of those principles which were steadily adhered to by the early breeders of short-horns, and which led to such unprecedented success.

Previous to the time of Bakewell and the Collings it was usually thought impossible to fatten an ox under five years old, and Mr. J. Baily, who wrote the history of Durham, says, "I remember going to see a curiosity in 1786, a steer, three and a-half years old, of Mr. Robinson's, of Hutton, that was supposed to weigh eighty stones (fourteen pounds), and sold for £20." One principal improvement which has been effected is that of an earlier maturity, short-horn cattle now readily fattening at two to two and a-half years old; secondly, an increased aptitude to fatten, or an increase in the relation of beef produced to food consumed; thirdly, undiminished milking properties; fourthly, the reduction of offal or useless portions of the carcase, including bone; fifthly, beauty of form and colour; sixthly, "quality;" seventhly, docility. All these excellences have been developed in a marked degree in the improved short-horn, without any deterioration of constitution or hardihood, by observing certain rules, simple in themselves, but requiring a discerning eye, a practised touch, an almost passionate attachment to the pursuit of cattle-breeding, and, lastly, a bold outlay of money. With these requisites the improvement of cattle becomes a certainty; without them, an impossibility.

The rules or principles which the breeder keeps before him are apparently simple, but involve in their successful application great judgment and long experience. First, it is an axiom that "like begets like," which fact brings us face to face with the whole question of judicious selection. Good animals beget good animals, but the power of transmitting valuable characters varies in individuals. The direct influence of the parent upon the offspring is backed up by the more remote effect of past generations. This singular fact, so well known to every one, and yet so mysterious, is termed *atavism*, from *atavus*, an ancestor, and leads us at once to consider the value of pedigree or lineage. Offspring may therefore resemble a remote ancestor, a fact expressed by the term "reversion," and exemplified by the fact that well-bred cattle will occasionally throw inferior calves, representing unimproved and remote progenitors. These must be rigorously "weeded." The longer a tribe of cattle has been purely bred, the less likelihood is there of reversion to a bad type, and hence the importance of purity of blood, or pedigree. Thus we see that individual merit and an unstained lineage must both be regarded as essential. It will now be perceived that the breeder's art is complicated by various considerations, such as the personal merits of parents, descent, the judicious pairing of animals with a view to correct defects or develop good qualities, and, lastly, the feeding and treatment of the animals.

It is also worthy of attention that however unnatural a system of breeding from near affinities may be, it has succeeded admirably in the case of short-horn cattle. We often hear in-and-in breeding, or the breeding from close relationships, at once condemned as leading to disease, deformity, and imbecility. All races of animals cannot, however, be thus generally spoken of. With some, as in the case of horses and the pig, in-breeding is followed with pernicious results, yet cattle and sheep may be bred in this way for many generations, with advantage rather than otherwise. The bold policy of in-breeding pursued by early short-horn breeders is indeed singular, and, we cannot help thinking, conclusive in favour of the system as applied to cattle. Let us now briefly trace the origin of the Barmpton and Ketton short-horns, from which so many herds of the present day are descended. The Messrs. Colling possessed good cattle of the neighbourhood, but Mr. Robert Colling confessed that they never had better cattle than other people, until Mr. Charles Colling purchased the cow Favourite and her daughter Young Strawberry from Mr. Maynard, of Eryholme. Other good cows were also gathered together at Barmpton, and such formed the nucleus of the future herd. We now turn to the sires. The first bull which left his mark was the now celebrated "Hubback" (319), a bull picked up almost accidentally by Mr. Charles Colling, but which was subsequently shown to be possessed of a pure short-horn pedigree for several generations. This bull possessed, in a most wonderful degree, the power of transmitting his good qualities to his offspring, and his name lies at the foundation of all the pedigrees in at least one very important section of our short-horn herds. "Foljambe" (263) succeeded "Hubback," and "Favourite" (252) succeeded "Foljambe." Favourite (252) was himself the result of close interbreeding, as is shown by the following tabular view of his pedigree, commencing with the cow Favourite and her daughter Young Strawberry.

$$\underbrace{\text{Young Strawberry (cow).}\quad \text{Foljambe (bull).}}_{\text{Bolingbroke (bull).}} \quad \underbrace{\qquad\qquad \text{Favourite (cow).}}_{\text{Phœnix (cow).}}$$

$$\underbrace{\text{Bolingbroke (bull).}\qquad \text{Phœnix (cow).}}_{\text{Favourite (252).}}$$

And yet Favourite was often used, without ill results, upon his own offspring for two generations. A cow by Favourite was put to Favourite, and the result was "Princess." Princess brought Nell Gwynne by Phenomenon (491), but on consulting the Herd Book we find that Phenomenon is by Favourite. Nell Gwynne put to Layton (366) brought another Nell Gwynne, and on investigating Layton's pedigree we find that he was by Minor (441), himself the result of two consecutive Favourite crosses, and out of a dam similarly imbued with Favourite blood. Again, taking the case of Janette by Wellington, a name which occurs far back in the pedigree of the "J" family, we find the following. Wellington was a grandson of Phenomenon, and by three previous crosses he was at once great, great-great, and great-great-great-grandson of Favourite. Still further, Janette's dam was by Phenomenon a son of Favourite, and, lastly, Janette's grandmother, great-grandmother, and great-great-grandmother were each by Favourite. Such was frequently the breeding of those earlier animals, whose progeny now rank highest in public estimation, and instances might be given to show that a similar system of close breeding has been pursued without apparent ill effects down to the present day.

At an early date in the history of short-horns two rival breeders, Mr. Bates, of Kirklevington, and Mr. Booth, of Warlaby, both of Yorkshire, came prominently before the public. It is scarcely too much to say that our most highly esteemed short-horns trace back to animals bred by either one or the other of these breeders. Booth and Bates' cattle are familiarly spoken of by short-horn breeders as representing two rival strains of blood, each party claiming special merits for his favourite. We do not propose to discuss this subject, as it would lead us into undue prolixity, but it is necessary to mention it, as the two strains are for the most part kept apart, and as a consequence certain distinctive characters have asserted themselves as peculiarly belonging to each family. Among the best examples of Bates' cattle at the present time are the Wetherby Duchesses, the property of Colonel Gunter; the Duke of Devonshire's herd at Holker, Lancashire; and Lord Dunmore's and Mr. Bowly's Kirklevingtons. Among Booth cattle we may mention the Warlaby herd, now in the possession of Mr. John Booth; the Aylesby herd, so long and carefully bred by Mr. Wm. Torr; and the Towneley herd, associated with the name of Colonel Towneley. We must conclude this brief account of short-horn cattle with the points of excellence usually looked for, many of which are common to other breeds of cattle.

The colour may be red, white, red and white, or roan, but black is not allowed on any part of the body. The hair is plentiful, long, lying in various directions, and of mossy, rich appearance. The animal is docile, the female carrying a sweet-looking head, with a quiet eye. Horns of moderate length in the cow; short, thick, and spreading in the bull. The muzzle is cream-coloured, and the horns are waxy, with streaks of red at the base. The bull has a noble carriage, and fine head, with hair curling over his forehead and between his horns. It is the head which gives what is termed "character" among

breeders. The rump-bone, when the animal is lean, should be about two inches off, and the upper portion of it level with, the under side of the tail. When an animal is narrow at this point there is often a want of lean flesh and substance between the rump and hips. The quarter, or length from rump-bone to hip, should be long and full of lean flesh; the hips should be wide across, especially in the female, and the hip-bones rounded and well covered; the loin must be flat and wide; the space between hips and ribs moderate; the ribs well arched and deep, giving a round "barrel;" the back straight; the breadth of the loin maintained by the spring of the ribs, and shoulders wide across; the belly line parallel with the back, giving a uniform cylindrical body; the flank well let down; thighs heavy-fleshed and deep; buttocks full on both sides; shoulders snugly laid back into the crops; the bosom deep, wide and prominent; the neck thick at the base, but tapering to the head; the head broad between the eyes, and tapering to the muzzle. Whether viewed from front, back, sideways, or from above, the animal should approximate as nearly as possible in general outline to a parallelogram form. This is difficult to realise, but a glance at truly well-made cattle will convince the observer that a certain squareness of form is the best type of bovine symmetry. In addition to a correct form, short-horns must also possess the essential trait of "quality" or "touch." In other words, the skin must be soft, pliant, neither too thin (papery) or too thick (heavy), and moving with a certain characteristic ease upon the cellular matter beneath. This peculiar handling of cattle accompanies aptitude to fatten, and it is spoken of as "quality." Quality is also indicated by an abundant coat of fine silky, well laid hair. On comparing Bates and Booth cattle, we find the following points of difference. The former are unrivalled in "touch" or quality; the bulls have grand "Bates' character" heads, noble necks, and upright shoulders, rather hollow or deficient behind. Mr. Carr, the historian of Booth cattle, says: "The late Mr. Booth succeeded in imparting a length of quarter such as no other herd can boast, a marvellous fulness and depth of thigh, and of the twist or junction of the inside of the thighs, and a perfectly parallel and almost perpendicular position of the hind legs. It was, however, to the ample and symmetrical development of the fore-quarters that Mr. Booth's special attention was directed. He increased the obliquity or backward inclination of the shoulder-blade, thereby preserving the level line of the back, and promoting the free and graceful carriage of the animal. It was also his aim to improve the form and enlarge the capacity of the chest, which he did by augmenting the prominence or circularity of the fore-rib, and the width of the sternum or floor of the chest. It is to the success of Mr. Booth's efforts in this direction that we are indebted for those valuable and almost peculiar characteristics of the Warlaby cattle—the perpendicular fore-flank, which drops even with the arm; the roundness of the barrel-shaped crops, and the width or massiveness of the projecting bosom. The necks of the Booth short-horns are remarkable for their bulky and yet symmetrical development, gradually swelling as they approach and blend with the shoulders and breast, and completely hiding the shoulder-points even in the unforced animal."

We are compelled to leave the short-horn here, and to turn our attention to other important breeds. Such a sketch must be of necessity incomplete; but if we have given a good general idea of the history of the breed, the principles kept in view by those agriculturists who interested themselves in its improvement, and some faint idea as to what a good short-horn is, our task has not been in vain. The following works have been consulted in writing the above article:—"The History of the Killerby, Studley, and Warlaby Short-horns," by W. Carr; "History of Improved Short-horn Cattle," by T. Bell; "The Rise and Progress of Short-horns," by H. H. Dixon; Darwin's "Animals and Plants under Domestication;" the *Agricultural Gazette;* Mr. Wright's Essay on Short-horn Cattle; and Mr. Thornton's "Short-horn Circular." In these any of our readers who may be desirous of obtaining further information will find many details, and much that is interesting and important that we have been precluded from entering into here. We need scarcely say that their perusal will amply repay the time spent over them, and furnish the cattle-breeder with many useful hints that might otherwise have been lost to him.

CIVIL ENGINEERING.—XIX.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*continued*).

The very limited period during which it was possible to work upon the Bell Rock—a period seldom exceeding three hours at a time—made it necessary to embrace every opportunity of favourable weather, as well by day as by torch-light by night, and also upon Sundays. The rise of the tide is so sudden that immediately the exterior parts of the rock were covered the workmen had to collect their tools, and betake themselves to the attending boats.

The first thing necessary to do at the rock was to erect a beacon to serve as a residence for the men during the working months. This beacon consisted of twelve large beams of fir timber, occupying a base of 30 feet diameter, and rising to a height of 50 feet above the rock. The spars were strongly framed with oak knees, and connected to the rock by iron bats set into holes, cut 18 inches deep in the rock, and wedged in. The upper part of the beacon was fitted up for occupation, the lower floor being employed as a smith's forge, and for preparing the mortar. Immediately over this was the cooking-house; above this were the cabins of the engineer and foremen, and over all the barracks for the artificers.

The occupied portion of this wooden structure was above the reach of the sea in moderate weather; but the lower floor was often lifted by the waves, and the contents washed away. The position of this beacon was near the site of the lighthouse, and after the erection of the latter had fairly progressed, the two structures were connected by a wooden bridge, which served as a stage from whence the materials employed in the building were raised from the rock. If the peculiar position and circumstances of the Bell Rock are taken into consideration, the great use of this beacon-house will be apparent. The rock was so constantly submerged, and the periods during which it was exposed were so short, and moreover the difficulty of landing upon the rock, owing to the violence of the surf, was so great, that had there not existed a temporary resort upon the rock itself, from which the workmen might without loss of time hasten to their duties, the commencement of the work would have been greatly impeded, and probably many lives lost. The beacon was vacated at the close of the summer, and again resorted to as soon as the storms of the ensuing winter and spring were over.

To facilitate the conveyance of the huge blocks of stone employed in the construction of the lighthouse, from the various landing-places at the rock to the site of the building, tracks of cast-iron rails were laid down and fixed to the rock. Two seasons were thus occupied in erecting the beacon, in cutting out and preparing the rock for the reception of the blocks, and in laying the first four courses of stone, which brought the height of the building 5 feet 6 inches above the foundation; and by the end of the succeeding season the building was raised to the height of 30 feet, which completed the solid portion of the lighthouse.

The state of the weather during the ensuing season, combined with the skill acquired by the men during the operations of previous years, enabled the building to be completed by the following October, at least so far as the masonry was concerned, and the light-room was finished in December of the same year.

This lighthouse is, like the Eddystone, circular. The two bottom courses of the masonry are sunk into the rock, and a very similar system of dovetailing to that of the Eddystone has been employed. The cement used was a mixture of pozzuolana, earth, lime, and sand, in equal parts by measure. The stones which compose the solid portion of the structure weigh from half a ton to two tons each.

The diameter of the bottom course is 42 feet, and the building diminishes in much the same proportion as the Eddystone, until the parapet-wall of the light-room is reached, where the diameter is reduced to 13 feet. The masonry portion is 100 feet high, above which the lantern rises 15 feet.

The first 30 feet from the ground is solid, and at this height the entrance is situated. The ascent from the rock to the entrance is by a kind of rope-ladder with wooden steps, which is hung out at ebb-tide, and taken into the building when the water covers the rock. The staircase rises 13 feet from the end

of the passage, at which place the walls are 7 feet thick, and diminish to 12 inches in thickness at the parapet-wall of the light-room. The building contains six apartments, including the light-room. The floors are all of stone. The casements of the windows are all double, and are furnished with outer storm-shutters. The parapet-wall is 6 feet high, and outside it is a balcony surrounded by a cast-iron rail, resting upon a footing of brass, and surmounted by a coping of the same metal. The smoke-tube of cast iron which conveys away the smoke from the kitchen passes through the several apartments above it, and heats them.

The light-room and apparatus was constructed in Edinburgh. Its shape is octagon, and it measures 12 feet across, and 15 feet in height. The sashes are of cast iron, and the panes measure 2 feet 6 inches by 2 feet 3 inches. The glass is $\frac{1}{4}$ inch thick. The cost of the building and its establishment was about £60,000.

It is easy to perceive that apart from the difficulty of rearing a tall structure having a limited area of base, which is submerged every tide, capable of withstanding the shocks of heavy seas, one of the chief obstacles to be contended against in erecting a lighthouse upon an isolated and exposed rock lies in the difficulty experienced in landing men and materials, and in the limited period of time during which operations can be carried on in the early stages of the work. Some idea of what this difficulty is may be gathered from the narrative of the building of the lighthouse upon the Wolf Rock, and of the admirable precautions which were adopted by the engineer, Mr. Douglass.

The Wolf Rock is situated 23 miles W.N.W. from the Lizard, 20$\frac{3}{4}$ miles E. by S. $\frac{1}{2}$ S. from St. Agnes Lighthouse, Scilly, and 7$\frac{3}{4}$ miles S.W. $\frac{1}{2}$ S. from the Longship's Lighthouse. It consists of a hard porphyry, and its highest part is 17 feet above low water, and 2 feet below high water of spring-tides. The surface is sufficiently rugged to render a landing upon it difficult at all times. The water is very deep on all sides except the S.E., the depth being upwards of 100 feet. There is also a strong tidal current setting upon the rock. Its position is exceedingly exposed, and it receives the full force of the Atlantic waves, which burst upon it with incredible fury. So long ago as 1823 the Admiralty appear to have wished to erect a lighthouse upon this rock, but the estimate of fifteen years to build it, and the cost—£150,000—seems to have deterred them from the enterprise, and an iron beacon was subsequently erected by Mr. Thurburn, occupying in its erection from 1836 to 1840. Five years would appear to be a long period to expend in this undertaking, but the actual time occupied in working upon the rock was only 302$\frac{1}{2}$ hours during the whole five years, this limited period being entirely due to the danger and difficulty attendant upon the exposed position of the rock. The beacon, which consisted of a mast of selected English oak 12 inches in diameter, secured by stays fastened to the rock, cost £11,298 4s. 1d., and it was carried away in November of the same year in which it was completed. It was replaced by one of wrought iron, 7$\frac{5}{8}$ inches in diameter, in August, 1842. During the heavy weather of the succeeding winter this iron mast was bent about 3 feet from the perpendicular, and in October, 1844, it was broken off at about 4 feet above the top of the cone. A second iron mast was subsequently fixed, the diameter being increased to 9 inches, but this also was carried away in the early part of 1848. Another iron mast of equal diameter, but supporting a smaller globe, was then fixed, and this withstood the violence of the sea until taken down, during the construction of the present lighthouse.

These particulars will serve to illustrate the force of the waves beating upon this rock. We shall not enter into a minute description of the magnificent structure which now serves to warn the mariner to avoid the dangers of the Wolf. A few of its leading characteristics will suffice.

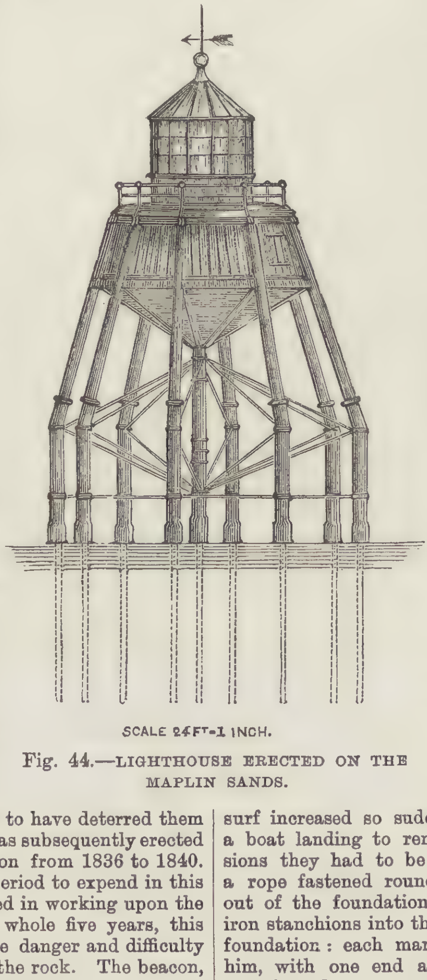


Fig. 44.—LIGHTHOUSE ERECTED ON THE MAPLIN SANDS.

The building is of stone, 116 feet 4$\frac{3}{4}$ inches high; the diameter at the base is 41 feet 8 inches, but near the top, just below the springing of the curve under the lantern, it is reduced to 17 feet. The work is solid for 39 feet 4$\frac{1}{2}$ inches from the base, with the exception of a space formed for a reservoir for fresh water. The walls are 7 feet 9$\frac{1}{2}$ inches thick at the level of the entrance door, and gradually decrease to 2 feet 3 inches at the thinnest part near the top. The exterior face of the shaft is similar to that of the Eddystone and Bell Rock, being perhaps rather flatter in the curve. It contains 44,506 cubic feet of granite, weighing nearly 3,300 tons. Every external stone block is dovetailed to the adjoining block, both vertically and horizontally, the dovetails being 3 inches in height. In addition to this precaution, each block of the two lower courses is secured to the rock by two metal bolts 2 inches in diameter, and sunk 12 inches into the rock and wedged. In the next eighteen courses each exterior stone is secured to the course below by two 2-inch bolts of yellow metal, and each internal stone by two 2-inch bolts of galvanised puddled steel. These bolts are sunk 9 inches into the course below.

In order to economise time upon the rock, the blocks were all prepared and carefully fitted, and the bolt-holes all bored, in the yard on shore. The blocks to the level of high-water spring tides were set in fresh Roman cement, and from this point upwards in Portland cement. The cement was mixed with an equal portion of sharp granitic sand, obtained near Penzance, and salt water was employed in the mixture for all the solid portion of the work. Very little wood is employed in the structure, the ladders for ascending from room to room being of cast iron, as well as the partitions between the rooms and the staircase; whilst the doors, windows, and storm-shutters are of gun-metal. To facilitate landing upon the rock, a landing-platform has been constructed. This consists of small granite ashlar, set in cement, the stones of which it consists being 24 inches × 12 inches × 6 inches, the quantity of masonry being 14,564 cubic feet.

It not unfrequently happened during the early stages of the work that the surf increased so suddenly as to preclude the possibility of a boat landing to remove the workers, and upon such occasions they had to be hauled on board through the surf by a rope fastened round their waist; and during the cutting out of the foundation pit, it became necessary to sink heavy iron stanchions into the rock at intervals around the site of the foundation: each man working with a safety-rope lying near him, with one end attached to the nearest stanchion. An experienced man was always stationed on the highest point on the rock, whose duty it was to watch for the seas, and to give warning to the workmen to hold on to the lines, when, with head to the sea, it would wash over them, and frequently carry away the tools they had been using. In this manner eight working seasons were passed, during which 266 landings had been effected, and 1,809$\frac{1}{2}$ working hours spent on the rock. In spite of the height of this lighthouse—upwards of 100 feet above high-water mark—large quantities of water are not unfrequently thrown over the tower. The total cost of the building, including all incidental expenses, was £62,726.

That most useful material, iron, is not excluded from the construction even of lighthouses, having been successfully employed in more than one instance. One will suffice as an illustration, the cast-iron lighthouse at Bermuda, erected by

Mr. Gordon. The site it occupies is not exposed to the wash of the sea; indeed, it might scarcely be deemed advisable to employ a material so liable to corrosion from the action of salt water as iron is, in a position where it would be subjected to its influence; it would certainly require the most constant and scrutinising attention.

The Bermuda lighthouse stands upon an elevation 250 feet above the level of the sea, and is itself 105 feet 9 inches high, and 24 feet in diameter at the base. It consists of concentric cast-iron plates, 135 in number, and moulded to the external contour of the shaft. The plates vary in thickness from 1 inch to $\frac{3}{4}$ of an inch, and are cast with flanges on the inside 4 inches broad, reckoning from the exterior surface of the plates, which are further strengthened by $\frac{1}{2}$-inch feathers placed at intervals of 12 inches.

Holes $\frac{3}{4}$ inch in diameter are drilled 6 inches apart in all the flanges, both vertical and horizontal, to receive $\frac{3}{4}$-inch screw-bolts, by which the several plates are united. In the centre of the lighthouse is a hollow column of cast iron running from bottom to top, 18 inches in internal diameter, and $19\frac{1}{2}$ inches in external diameter. Upon this rests the optical apparatus, and the weight by which its revolution is maintained descends through this hollow shaft. The column is cast in nine lengths, each length terminating externally in broad circular flanges, which serve the double purpose of connecting the sections together, and of supporting the floor-plates. This shaft is also employed in raising stores from one floor to another, for which purpose there is, at a height of 2 feet above each floor, an opening left, 26 inches high and 15 inches wide, furnished with a door. The lower portion of the tower is filled with concrete to the height of 20 feet, with a well in the centre 8 feet in diameter, lined with brickwork. There are seven floors, each 12 feet high, the lower two being cased with brickwork. The upper five are lined with sheet iron. Each floor is furnished with five windows, 18 inches square, fitted with plate glass. The staircases, with the exception of the treads, which are of oak, $1\frac{1}{2}$ inch thick, are wholly of iron. The light is visible at a distance of upwards of eight leagues. The total cost was under £8,000.

There is a cast-iron lighthouse erected upon the Fastnet Rock, an isolated crag situated a few miles off the southernmost point of Ireland, and rising 60 feet above high-water mark. The dimensions of the tower are—height from base to gallery, 63 feet 9 inches; height of lamp above the gallery, 11 feet; height of lantern, 30 feet; outside diameter of base over the stone moulding, 23 feet; outside diameter of cast-iron shell at base, 19 feet; outside diameter below the cornice, 13 feet $11\frac{1}{4}$ inches; thickness of plates at the base, $1\frac{3}{8}$ inch; thickness at top, $\frac{7}{8}$ inch. The mode of construction is nearly identical with that at Bermuda.

When a lighthouse is required to stand upon a soft, yielding base, as sand, screw-piles are employed with great advantage. There are several instances of such structures. One of the earliest is that at the Maplin Sands, erected in 1841. The building rests upon nine wrought-iron piles, 26 feet long and 5 inches in diameter, furnished with cast-iron screws, whose blades are 4 feet in diameter. The piles are screwed into the sand to a depth of 22 feet, leaving 4 feet standing above the soil. One pile occupies the centre of the building, and the remaining eight stand at the angles of an octagon formed round the central pile. The upper portion of the piles enter the hollows of cast-iron sockets forming the lower extremities of the supporting columns. The central column is perpendicular, the remaining eight incline inwards, and the whole nine support the platform, house, and lantern. The columns are strongly braced together by wrought-iron rods, the braces being horizontal below the water-line, supporting the columns at a point midway between the top of the piles and the bend of the columns; and diagonal from the angle of the bends themselves to the central column, rising and falling above and below the horizontal plane of the bends. The entire absence of opposition to the waves offered by the columns is a notable and excellent feature in this form of structure.

In Fig. 44 we give a sketch of the lighthouse erected on the Maplin Sands.

There are many other lighthouses erected upon piles, all of which have stood well. That at the *Gunfleet* stands on seven screw piles, screwed 40 feet deep into the sand. Another, at the *Point of Ayr*, stands on nine piles, screwed 12 feet into the sand. There is a small lighthouse standing upon piles at *Mucking Reach* in the Thames, a few miles below Gravesend.

A remarkable and successful instance of lighthouse engineering occurred some years since at Sunderland. Owing to the construction of a jetty, the lighthouse, which had stood upon the old pier, became useless in that position, and it became necessary either to pull it down and rebuild it upon a situation where it would be of use, or to remove it bodily. The distance of the new site from the old was no less than 475 feet, and was not in one direct line, and the difficulty and risk attendant upon adopting the latter course will readily be appreciated: adopted it was, however. The weight of the structure was 757,000 lb.; it consists of an octagonal tower 64 feet high, and 15 feet in diameter at the base; and not only had it to traverse the distance mentioned, but it had to be turned upon its axis, and the new site was 19 inches higher than the old.

The method employed was generally much the same as that employed in the removal of large masses of masonry, with certain modifications to suit the shape of the building. A series of openings were made in the base of the tower, and into these beams were introduced, united together by cross-beams, so as to form a substantial and very strong flooring or platform of oak. In order to steady the tower, a framework of shores or props, resting on the platform, abutted against the tower from the base to the summit, the stays being strengthened by crossbeams.

The platform rested on 144 cast-iron flanged wheels, and the masonry below the platform having been very gradually removed, iron rails were introduced below the wheels, and thus by degrees the whole structure was made to rest upon the wheels, which ran on eight parallel rails, laid upon the pier, along which the lighthouse was required to move. The whole mass was moved forwards along the rails by iron chains attached to the platform, and wound upon windlasses. The entire operation was accomplished in about $13\frac{1}{2}$ hours, and so successfully that no interruption occurred in the lighting of the lantern, not even for a single night.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XV.

BY E. WYNDHAM TARN, M.A.

PLUMBER.

THE work of the plumber consists in the laying of lead on the roofs, gutters, etc., of buildings; lining wood cisterns with lead; laying down lead or iron pipes for water-supply; fixing cocks, water-closet apparatus, soil-pipes, pumps, etc.

There are two kinds of lead used for roofs and linings to cisterns, cast lead and milled lead; the former is now seldom used, though it is often found on old buildings. Milled lead, which is now generally used, varies in thickness, which is reckoned according to the number of pounds' weight in each square foot, as 4 lb., 5 lb., 6 lb., etc. In measuring plumbers' work take the exact area of the lead, describing the weight per foot, and multiply the area by the given weight in the abstract, which will give the weight of lead used. In the bill all sheet lead is brought into cwts. and lbs., and the different parts of the work kept separate. In taking the dimensions of lead covering to roofs, sufficient allowance must be made for the laps and dressings over the rolls; and in gutters an allowance is to be made at the drips for turning up the lead.

In taking the lead linings to cisterns, measure the exact quantity of lead, take the run of the soldered angles, and also the nailing to the edges with copper nails. Number the solderings for letting in pipes, washers, etc., to the cisterns, also all plugs, washers and wastes, air-traps, screw or driving ferrules, stop-cocks, bib or ball cocks, stating whether zinc or copper balls are used, and giving the size or diameter of the bore of each cock.

All lead pipe is taken by the foot-run, the diameter of bore being stated, and whether common, middling, or strong pipe is used. The soldering to the joints, which are required in laying or connecting pipes, is generally included in the price of the pipe and laying; but solder joints for attaching cocks, etc., are numbered, describing the size of pipe. Syphon traps formed by bending pipes are numbered as extra upon the measured length. Trumpet-mouthed standing water-pipes in cisterns are numbered, giving the height and diameter at bottom; also

number the lead service-boxes soldered into the bottom of the cistern for the supply of the water-closet. The apparatus for water-closets are numbered and described; the D or P traps thereto are numbered separately, and the soil-pipe by the foot-run, describing the diameter and weight per foot; bends to soil-pipe are measured separately from the straight part, and all soldered joints are numbered. The lead safe, laid underneath the closet apparatus, is measured by the foot superficial as in cisterns, and the soldered joints by the foot-run.

Pumps are numbered, describing the diameter, and whether suction or force pumps, single or double; the pump-rods for deep wells are in lengths of 10 feet with joints and brass couplings, and must be measured by the foot-run.

ZINC-WORKER.

Zinc is used in a similar manner and for similar purposes to those for which lead is applied, as in the covering of roofs and flats, valley and hips, flashings, linings of gutters and cisterns. The area is measured with proper allowance for laps and rolls, and if cut away at a slant the full width of the widest part must be measured, and no deduction made for the part cut away, as there would be in lead. The thickness or gauge is stated as so many ounces to the foot, but it is not brought into cwts. and lbs. in the bill, the price being stated at per foot superficial, according to the position in which it is laid, whether in flats, roofs, gutters, flashings, corrugated, etc. Zinc eaves, gutters and rain-water pipes are taken and billed out at per foot-run, numbering the heads, shoes, bends, nozzles, stopped ends, angle-pieces, etc.

GAS-FITTER.

The pipes used for conveying gas to various parts of a building are of two kinds, iron and tin; the iron pipes being used for the principal part of the work, and in carrying the gas from floor to floor, and the tin pipes for branching therefrom to the burners and chandeliers. The iron pipe is in lengths of from 4 ft. to 12 ft., and must be measured with an allowance of so many lengths: if short pieces of 2 ft. to 4 ft. are used, they are measured separately at per foot, pieces under 2 ft. being numbered; the internal diameter of the tubing must be stated. Number all bends, elbows, tees, cross-pieces, connecting pieces, plain or diminishing sockets, flanges, union joints for tin pipe, stop-cocks, nose pieces, etc. Tin gas-pipe is to be measured by the foot length, describing the diameter. Gas brackets are numbered and described, giving the length of the tube, whether single, double, or treble jointed. Pendants, chandeliers, standards, etc., are numbered and described.

GLAZIER.

In measuring the glass stopped into sashes, sash doors, fanlights, skylights, etc., take the dimensions between the rebates, if the opening is rectangular, and the greatest width and length, if the shape is irregular; bring into superficial feet, describing the size of the squares, and the quality of the glass, whether best, seconds, or thirds crown; if sheet glass, state the number of ounces per foot superficial, as well as the quality; if plate glass, state whether best or seconds glazing quality, the size of each square and the thickness. If the glass has to be bent to a sweep, it is measured extra per foot superficial.

Glazing in lead quarries, with crown or cathedral glass, is taken by the foot superficial, including the lead-work and copper ties, an allowance all round being made for letting into the groove in the stone-work; and if the heads are arched they must be measured the full height by the width, as if square. Saddle bars are taken separately, by weight, with the smith's work.

Hacking out old or broken glass is taken by the foot superficial, in addition to the stopping in of the new glass. Also obscuring or frosting glass to imitate ground-glass is taken by the foot superficial.

Cleaning windows is numbered by the window, and if in small squares of glass, by the dozen squares. Grinding or polishing the edges of plate glass is taken by the inch-run, and circular cutting by the foot-run. Glass tiles or slates are numbered according to their respective sizes.

PAINTER AND DECORATOR.

The painter's work on deal or other woods must be measured separately from that on plaster, cement, iron, or other material; as in painting on deal the work has first to be knotted, and any defects stopped, and then primed, after which it receives the stated number of coats, generally described as so many oils. All large works, as doors, framing, walls, etc., are measured by the yard superficial, with an allowance for all edges, mouldings, sinkings, projections, etc., in taking the dimensions. Carved work may be taken by the foot superficial. Skylights of large size may be measured by the superficial yard, but entered separately in the bill.

Where the work has to be cut in on one or both edges, as in edges of stairs cut for carpets, skirtings, rails, newells, rain-water pipes and gutters, reveals, cornices, staff beads, shelf edges, strings of stairs, etc., it is taken by the foot-run.

The paintings to sah frames is taken by number, describing the size, and whether ordinary or Venetian. Sashes and casements have the number of squares taken by the dozen, if small, but large squares are taken singly.

Iron railings and balusters of stairs have the painting measured, as if it was solid work, the height by the length on both sides.

Small articles, as bell-boards, scrapers, shutter-bars, chimney-pieces, etc., have the painting to them taken by number and description.

Graining and varnishing is measured by the yard superficial, except for hand-rails, which are taken by the foot-run; the character of the imitation is described, and also the number of coats of varnish.

The description of painter's work must include the number of coats laid on, whether finished in common or extra colours, or with a flatting coat; also whether prepared for graining. In repainting to old work it must be described as rubbed or pumiced down previous to being painted.

Staining, sizing, and varnishing deal, in order to bring out the natural grain of the wood, is measured by the superficial yard.

Writing or painting letters or figures is taken by the inch-run, describing the height and character of the letters, and whether plain or shaded.

Gilding is measured by the foot superficial, carved work being taken separately; and mouldings by the foot-run, describing the size.

Distempering is measured by the superficial yard, describing the tints used, and if more than one. Imitations of Scagliola are measured by the foot superficial.

PAPER-HANGER.

The hanging of paper to walls is measured by the foot superficial, and the area thus found is entered in the abstract and divided by 5, to bring it into linear yards of paper 20 inches in width, which quantity is divided by 12, to bring it into pieces, as nothing less than a piece of 12 yards length can be taken. Common papers, however, do not nett more than 11 yards to the piece in the general way, so that a full allowance must be made. If the paper is hung to new walls, describe the sizing of the walls, and hanging with a lining paper previously to hanging the decorative paper. If the walls have been previously papered, then take the pumicing, sizing, and stripping with the description of the papering.

Canvas lining over panelled framing, or where the surface is not even, is measured by the superficial yard. If the paper is hung in blocks, as marbled papers, or if in panels, it must be so described, and whether lined, sized, and varnished.

Borders to paper-hangings are taken by the dozen yards, unless of superior quality, when they may be taken by the single yard.

Gold or black mouldings fixed upon the papering with needle-points are measured by the yard-run, describing the width.

We shall now apply the foregoing rules to taking out the quantities in each of the above-named trades, and then proceed to form an abstract thereof, previously to bringing them into bill.

PLUMBER.

2)	24 0 15 0	720 0	7 lb. milled lead on roof.
	25 0 1 6	37 6	6 lb. ditto gutters.

2) 30 0 1 9	105 0	Ditto, ditto, hips.
34 0 1 3	42 6	5 lb. ditto step flashgs.
15 0 2 6	37 6	6 lb. ditto cisterns.
5 0 2 6	12 6	7 lb. ditto, ditto.
17 6	17 6	Soldered angle to cistern.
15 0	15 0	Close nailing with copper nls.
45 0	45 0	1 in. strong lead pipe.
12 0	12 0	¾ in. ditto.
35 0	35 0	1¼ in. ditto.
16 0	16 0	1½ in. ditto.
32 0	32 0	5 in. soil-pipe.

No. 2 solder jts. to 1¼-in. pipe.
,, 2 ditto, 1-in. pipe.
,, 2 ditto, ¾-in. pipe.
,, 2 ditto, 1½-in. pipe.
,, 2 1¼-in. brass washer and waste.
,, 1 1¼-in. trumpet-shaped standing waste 2 ft. 3 in.
,, 1 lead service-box, soldered.
,, 1 1¾-in. ball-cock and copper ball.
,, 1 1-in. stop-cock.
,, 1 ¾-in. bib-cock.
,, 1 D-trap.
,, 1 W. C. apps.
,, 1 syphon-trap in 1½-in. pipe.
,, 1 brass gratg., soldered.
,, 1 2½-in. br. force-pump.

ZINC-WORKER.

12 0 10 6	126 0	25 oz. zinc in flats.
24 0	24 0	4 in. eaves gutter.
2) 15 0	30 0	2½ in. R. W. P.

No. 2 octagon heads. 2 shoes. 2 nozzles.
,, 4 stopped ends to gutters.

GAS-FITTER.

55 0	55 0	1 in. w. iron welded tubing.

No. 5 short pieces 1 in. w. i. tubing.
,, 3 bends to ditto.
,, 2 tees to ditto.
,, 1 cross to ditto.
,, 1 connecting piece.
,, 1 1-in. stop-cock.

30 0	30 0	½ in. tin pipe.

No. 8 ½-in. union joints.
,, 4 plain brackets, 12 in. long.
,, 2 ditto, double jointed, 24 in. ditto.
,, 1 plain pendant, with hydraulic joint.
,, 5-light chandelier.

NOTABLE INVENTIONS AND INVENTORS.

XXIX.—SIR ISAMBARD BRUNEL (*continued*).

BY JOHN TIMBS.

We mentioned at the conclusion of the first part of this memoir the machine invented by Brunel for making shoes for the army. After two years' trial the manufacture of shoes by this machine was given up from an economical motive. By this and another speculation Brunel got into difficulties, from which he was extricated by a Government grant of £5,000, in consideration of the savings by the use of his block machinery. He then improved the stocking-knitting frame and the steam-engine, the manufacture of metallic paper and crystallised tinfoil, stereotyping, and the treadmill. Among other things he invented machines for making wooden boxes; for nail-making; for ruling paper; a contrivance for cutting and shuffling cards without the aid of the fingers, produced in reply to a playful request from Lady Spencer; a hydraulic packing-press; and a process for building wide and flat arches without centerings. In steam navigation he experimented with a boat on the Thames, fitted with a double-action engine, and made his first voyage in it to Margate in 1814, when he narrowly escaped personal violence from the proprietors of the sailing-boats. Marine engines and paddle-wheels were next improved by Brunel. He constructed a machine for using carbonic acid gas as a motive power; and, assisted by his son, carried on a series of experiments for more than ten years in the endeavour to bring it to perfection. Most of the mechanical difficulties were overcome; but although an intense power was obtained, and with a very low temperature, the economical advantages, as compared with the cost of the vapour of water, did not appear to be such as to compensate for the increased cost of the machinery and the usual difficulties in its use.

In different parts of the United Kingdom are to be found works of engineering construction by Brunel, who thus largely contributed to the wonders which in his boyhood he so ardently desired to see. His greatest work, and that by which he is most popularly known, is the Thames Tunnel, a brick-arched double roadway under the river, between Wapping and Rotherhithe. In 1804, two Cornish miners, Varey and Trevethick, commenced an archway from Rotherhithe to Limehouse, and the excavation had reached 1,040 feet, when the ground broke in under the pressure of high tides, and the work was abandoned. With such failure before them, fifty-four engineers declared it impracticable to make a tunnel under the Thames of any useful size for commercial purposes. Brunel, however, rose superior to this declaration, and planned a tunnel in 1823, when a company was formed, and the Duke of Wellington and Dr. Wollaston were the earliest subscribers to the scheme. A brickwork cylinder, 50 feet in diameter, 42 feet high, and 3 feet thick, was commenced by Brunel, at 150 feet from the Rotherhithe side of the river. Upon this cylinder, computed to weigh 1,000 tons, was set a powerful steam-engine, by which the earth was raised and the water was drained from within it. The shaft was then sunk into the ground *en masse*, and completed to the depth of 65 feet; and at the depth of 63 feet the horizontal roadway was commenced, with an excavation larger than the interior of the old House of Commons. Brunel devised, in 1814, this plan of operation from the bore of the *Teredo navalis* into the keel of a ship, the perforation of the worm being secured at the sides, and lined with a calcareous secretion, so as to be impervious to water. With the auger-formed head of the worm in view, Brunel employed a cast-iron *shield*, containing thirty-six frames, or cells, in each of which was a navvy, who cut down the earth; and a bricklayer simultaneously built up from the back of the cell the brick arch, which was pressed forward by strong screws. Thus were completed 540 feet of the tunnel, when the river burst into the works; but the opening was soon filled up with bags of clay, the water pumped out of the tunnel, and the work resumed. At the length of 600 feet, the river broke in again; six men were drowned, and the rush of the water carried Mr. Brunel's son up the shaft. The tunnel was again emptied, but the works were suspended seven years for want of funds.

In April, 1834, several members of the Royal Society, with Mr. Brunel, one of the vice-presidents, visited the tunnel to its extreme end, and Mr. Brunel showed the whole progress of the work, the great difficulties that had already been overcome in

carrying the tunnel above 600 feet under the Thames; and the data being explained upon which the engineer confidently anticipated being able to complete this great undertaking, if the necessary funds were supplied. Brunel, at considerable length, detailed the exertions which had been made to overcome the difficulties arising from the irruption of the river, and stated that in the course of the work the miners had for twenty-seven days pushed on the tunnel over a quicksand.

The members of the Royal Society, after leaving the tunnel, proceeded to view an experimental arch constructed on a new plan by Mr. Brunel. This structure was built of bricks and Roman cement, and consisted of two semi-arches, springing from the same pier, without any support. By this plan an arch of the greatest span might be constructed without centering, and demonstrating, as the projector observed, the practicability of building a tower of brickwork 50 feet high and 200 feet in diameter, and sinking the whole gradually in one mass. By this method it was intended to complete the circular and winding carriage approaches to the tunnel. It may be interesting to observe that of the two semi-arches one was shorter than the other, and it had been loaded with about eleven tons of iron for the previous nineteen months without any sensible change in its position.

Mr. Brunel was not, however, discomfited by catastrophes in his tunnel, though, as Tom Hood sings—

"Sad is it, worthy of one's tears,
Just when one seems the most successful,
To find one's self o'er head and ears
In difficulties most distressful;
Other great speculations have been nursed
Till want of proceeds send them on a shelf:
But thy concern was at the worst
When it began to *liquidate* itself."

Many plans were now proposed for completing the tunnel, and above £5,000 were raised by public subscription. By aid of a loan sanctioned by Parliament, mainly through the influence of the Duke of Wellington, the works were resumed, and a new shield constructed in March, 1836, between which date and November, 1841, the shaft at Wapping was reached. The new shield consisted of 5,000 pieces, and weighed 150 tons. On March 24, in the same year, Brunel was knighted by Queen Victoria; on August 12, he passed through the tunnel, from shore to shore; and on March 25, 1843, it was opened as a public thoroughfare. On July 26, 1843, it was visited by Her Majesty. The tunnel cost about £454,000, exclusive of the carriage descents. The dangers in the progress of the works were many; yet, with all these perils, only seven lives were lost in constructing the Thames Tunnel, whereas forty men were killed during the building of the present London Bridge. At full tide, the foot of the tunnel is seventy-five feet below the surface of the water. Brunel has left a minute record of his great work in Weale's "Quarterly Papers on Engineering." A fine medal was struck on the completion of the tunnel—*obv.*, the head of Brunel; *rev.*, interior and longitudinal section of the tunnel.

This was the engineer's last work. Commercially, it proved disastrous, which preyed upon the mind of Sir Isambard Brunel, though he lived six years longer, until he had attained his eighty-first year, in 1849, when he died at his house near St. James's Park. In the gallery of portraits of inventors at South Kensington is an engraved portrait of Brunel, from the painting by S. Drummond, A.R.A. As a triumph of engineering skill, the tunnel is complete. Brunel's inventions, and their essential usefulness, show what may be accomplished by genius, seconded by industry and indomitable perseverance.

SANITARY ENGINEERING.—XXII.

THE VENTILATION OF HOUSE DRAINS AND THE DISINFECTION OF SEWER GASES.

In a previous paper we have given some instructions as to the ventilation of pipes—a subject to which hitherto we are afraid public attention has scarcely been sufficiently directed; and we now have to devote a similar amount of attention to the ventilation of house drains. As we proceed further we shall have to consider the question of the ventilation of public sewers; but this important subject has already, from the force of circumstances, fully occupied the attention of competent authorities, and the materials with which we have to deal are ready to our hand. In the present case it is not so; it is only within the last few years, or few months, we may say, that attention has been sufficiently drawn to the matter in hand, although it is one of the most important features of sanitary engineering.

In olden times—*i.e.*, before the last thirty years or so—when the greater part of our house drainage was carried by the old-fashioned brick-built "barrel-drain," the porosity of the brickwork, and the occasional imperfection of the joints provided, as it were, a system of natural ventilation, and although the subject really never had due consideration, the drains to a great extent ventilated themselves. But now that thoroughly glazed impervious pipes are used, with all the recent improvements in their manufacture, this is not the case; and if the matter is not duly considered and provided for, the better the character of the actual workmanship of the drainage, the greater the danger to health if ventilation is neglected, as the drains then become so many ducts for sewer gas, which is drawn into the house, and may, and not unfrequently does, exercise a most prejudicial influence on the health of the inhabitants. In rural districts, with detached and independent systems of drainage, as alluded to in our last paper, the question is comparatively easily dealt with, as if the reservoir or cesspool is away from the house, and is properly ventilated, no further danger can arise, except from an occasional or accidental obstruction; but in town houses, more especially large establishments draining into a large general system, further precautions are required, and as to the method of their practical adoption we give the following details.

In Fig. 47 is shown Mansergh's Patent Ventilating Trap. The section S is the pipe from the sink, drain, or closet, as the case may be. G is an open grating for surface-water, the water-line being clearly shown, and P is the ventilating pipe by which the sewer gas is allowed to escape. Objection is sometimes taken to allowing an escape of sewer gas "under the windows," as the phrase goes, as houses in streets must, of course, obtain their light and air from front or back. The remedy in this case is to carry the ventilating pipe up to the top of the house—not by any means a costly matter, as a common cast-iron rain-water pipe will answer the purpose perfectly—and the sewer gases are then discharged into the atmosphere at the level of the chimneys, where they are dissipated in the air, and become perfectly harmless. In cases where from peculiarities in the construction or position of the house this is difficult, still a ventilator of some sort should always be provided; and this axiom may be safely adopted, that outside the house sewer gas is rarely or never dangerous, but that it is when freely admitted within that its deleterious effects are felt. And here we may remark that water possesses an extraordinary power of absorbing these peculiar gases, and that the waste-pipe of a closed cistern may become the means, if improperly constructed, of impregnating the drinking-water of a whole family with ingredients which may without exaggeration be called poisonous.

We next give an illustration showing the facilities for ventilating a system of drainage at any part of its course, with the benefit of using a cane for the removal of obstructions. The system is known as Lovegrove's Patent, and may be employed either with or without a separate ventilating shaft if left open at the top. Fig. 48 shows the construction with the ventilating pipe, and Fig. 49 without it.

These are, of course, not the only methods in use; there are many others, but we quote those given as lucidly illustrating and exemplifying the principles to be adopted, and we now proceed to the second head of our subject—the disinfection of sewer gases. This is a question only recently brought before the public in a practical form, and the agent hitherto found most efficient, and therefore most generally used, is charcoal. We quote Dr. Watson on the *rationale* of its use:—

"All decaying animal and vegetable matters give off during decomposition fœtid and deleterious gases, which in the end tell as fatally upon the human constitution as the bite of a viper, or the most insidious poison known to the chemist. These deadly gases become in their passage through charcoal inodorous, and comparatively harmless. The explanation of this result is beautiful and simple.

"Charcoal is an extremely porous substance, presenting throughout its mass an almost incredible amount of surface, and upon this depends its power of absorbing various gases in

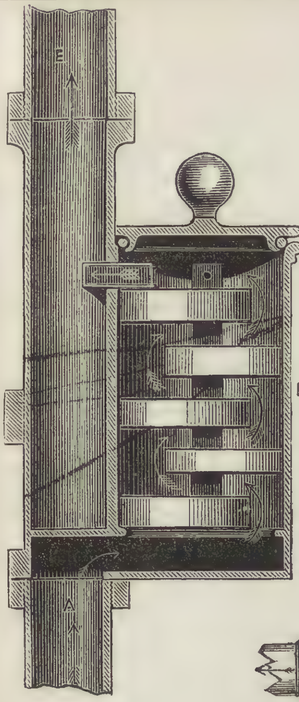


Fig. 50.

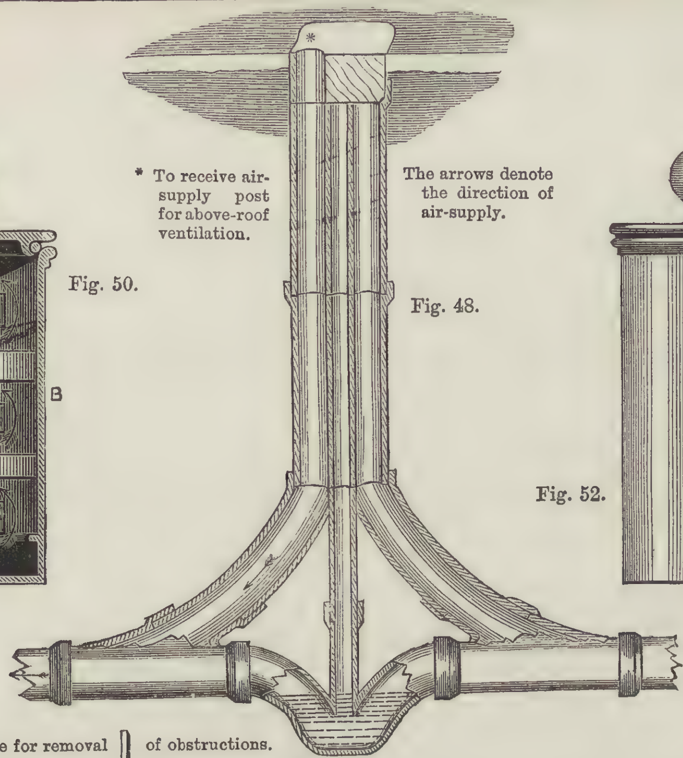


Fig. 48.

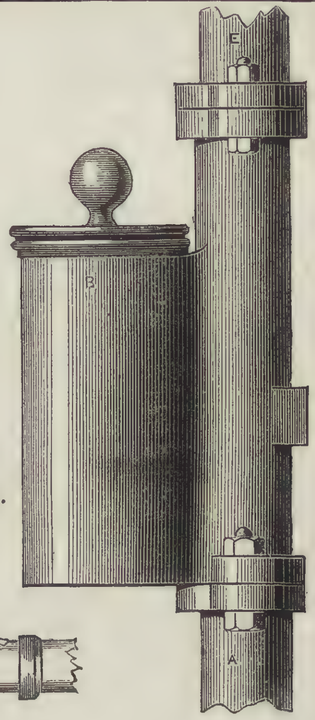


Fig. 52.

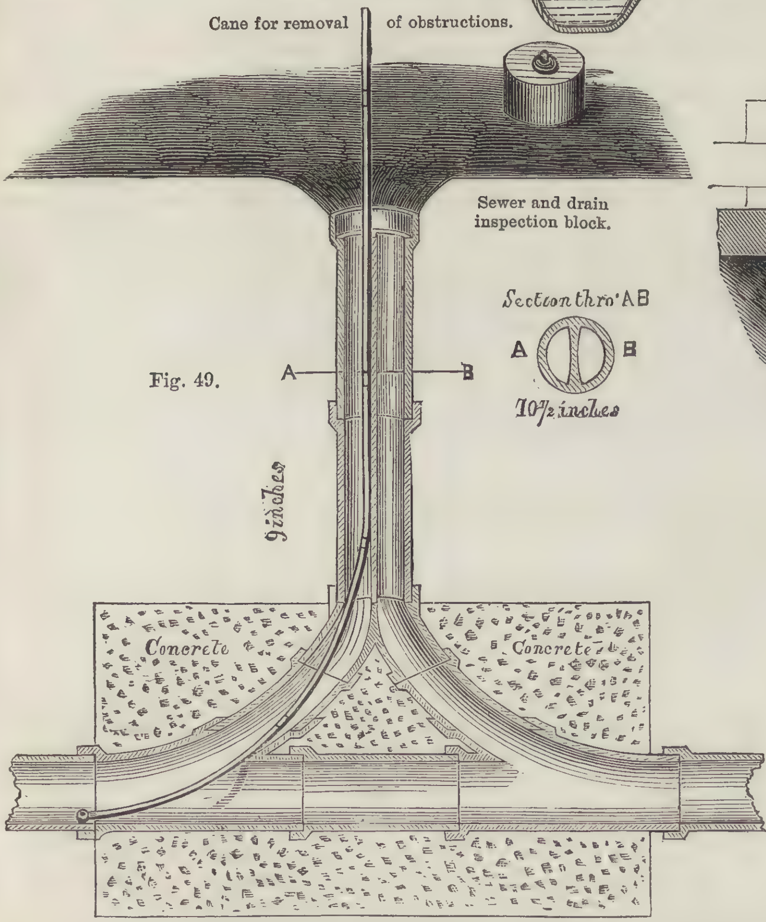


Fig. 49.

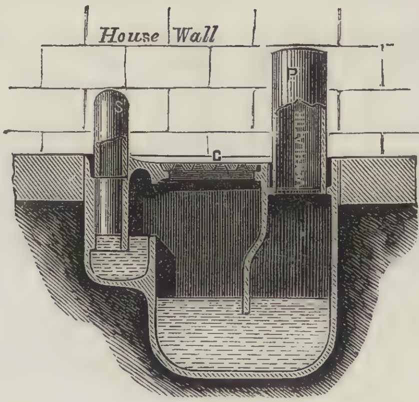


Fig. 47.

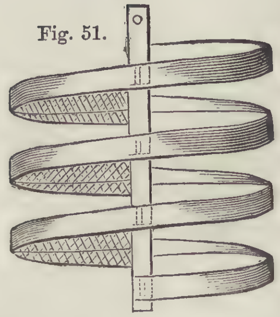


Fig. 51.

large quantities. The oxygen of the air is the great vivifier of nature. The deadly emanations given off by decomposing matters are in what is called a low state of oxidation—that is, they contain a comparatively small proportion of oxygen; combine them with, or force them to take up more of this purifying element, and the point is gained—that which perhaps an instant before would have proved most hurtful if breathed, becomes now entirely resolved into comparatively harmless combinations. Now, as charcoal contains within its pores a very large proportion of oxygen, amounting to rather more than eight times its bulk, its efficiency as a disinfecting agent is thus satisfactorily proved, not only in theory, but also practically by experiment."

There are many ways of employing it. In one of our previous papers we gave a sketch of a patent trap invented by Mr. Cottam, the engineer, where the ventilator at the ground level was covered or protected by a layer of charcoal; and we now proceed with some sketches of another adaptation of the same principle. Referring to the earlier part of our article, recommending the adoption of a ventilating pipe, we now show how the gases passing up this pipe may be thoroughly deodorised by the intervention of a series of shelves containing charcoal (Fig. 50).

In this A is the upcast pipe from the drain, B the ventilator containing the shelves, and E the pipe that discharges the deodorised gases into the open air. These trays may be replaced by a spiral tray, as in the sketch below (Fig. 51), known as Latham's patent. Fig. 52 shows the outside appearance of the disinfecting apparatus when fixed complete.

The above illustrates the general principle, which is capable of many modifications. In a large pauper asylum recently erected at Wandsworth the object was specially provided for by means of flues constructed in the body of the building, and carried up to the highest point of some angle towers, that form a marked feature in the elevation; at the topmost level boxes of charcoal were provided, through which the sewer gases, thoroughly disinfected, were allowed to escape into the open air.

The same result may be attained by various other chemical means, into which our space will not allow us to enter in the present paper; but in a later branch of the subject, the ventilation of sewers as distinguished from house-drains, we may probably deal with the question in rather fuller detail.

Whenever from circumstances the outfall of the drainage of any particular district takes place during only a few hours of the twenty-four, ample provisions for the ventilation of house drains are most especially requisite. We may instance some of the low-lying districts adjoining the Thames, for which, when the tide is high, the sewers are what may be called water-locked for perhaps more than twelve hours out of the twenty-four; and the recent shortcoming so prominently brought before public notice in the case of Scarborough is another exemplification of a similar state of things. Another point worthy of attention is the fact that the greater portion of sewage water, properly so called, passes through the drains during the day only; the quantity passing during the night being comparatively small; while the rainfall only is, of course, about equally divided as a matter of average during the twenty-four hours; although storm-waters, as they may be called, at certain times of the year fall in such quantities within sometimes the space of an hour or two as entirely to overcharge all ordinary systems of drainage. These, however, are not much to be feared upon sanitary grounds, as their first action is thoroughly to flush the drains, and wash away the sewage properly so called, the surplus or overflow consisting for the most part of rain-water only, which has to find its way by degrees, when the drains are overcharged, through the adjacent ground.

We need hardly say that when any system similar to Moule's is introduced, the remarks and illustrations of this paper do not apply to the case with equal force, although even then, the necessary constructions for the removal of rain, surface, and subsoil water are all the better for due provision being made for their thorough ventilation.

In our next paper we shall take up the question of the construction of sewers; giving a certain amount of attention to village and suburban districts, and probably a few particulars as to the last improvements in construction, as adopted in our recently completed metropolitan system.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXII.—BENJAMIN ROBINS.

BY JAMES GRANT.

THIS celebrated English mathematician, philosopher, and experimentist was born at Bath in the year 1707. Although his parents, who belonged to the Society of Friends, were unable to give him much education, yet so strong was the inborn vigour of his own mind, that he taught himself various branches of knowledge, and more particularly the science of mathematics, of which his friends wished him to become a teacher, and to settle in London. With this view he travelled to the metropolis, carrying with him a letter of introduction to Dr. Pemberton, who conceived and expressed a very high opinion of his scientific acquirements.

To prepare himself more fully for the important office of tuition, he perused the works of the most eminent mathematicians, and while in the course of these studies he was led to demonstrate the last proposition of Sir Isaac Newton's "Treatise on Quadratures," which appeared in the *Philosophical Transactions* for the year 1727.

In the year following Robins published "The Present State of the Republic of Letters," in refutation of the dissertation of John Bernouilli on the laws of impact in moving bodies. The paper referred to was the production of John, brother of James Bernouilli, the famous mathematician of Basle, and it had lost the prize offered by the Academy of Sciences in 1726.

Having now brought himself before the world of letters as a mathematician, Robins relinquished the peculiar costume of the Society of Friends, and began to take pupils; but the great activity of his mind, however, did not permit him to be satisfied with his theoretical studies; and singularly enough, for one who had been reared in the peaceful tenets of Quakerism, he began a series of the most elaborate experiments in gunnery, with the view of establishing the influence of the resistance of the air upon projectiles. He also directed his attention to the various branches of a great art that was as yet in its infancy—civil engineering; and he made several tours in the Low Countries for the purpose of studying fortification.

In 1734, on his return to London from one of those tours, he found the scientific world in a state of commotion occasioned by the publication of the "Analyst," by the learned Dr. George Berkeley, Bishop of Cloyne, in which that ingenious author attempted to refute the Newtonian doctrine of fluxions. He further styled Dr. Halley an "infidel mathematician," and endeavoured to prove that mysteries in faith were unjustly objected to by mathematicians, who, he thought, admitted much greater mysteries and even falsehoods in science, of which he affirmed the doctrine of fluxions was a pregnant example. This occasioned a long and angry controversy between the bishop and many men of science. Robins requested special permission to devote himself to a refutation of the charge, and accordingly in 1735 he published "A Discourse concerning the Nature and the Certainty of Sir Isaac Newton's Method of Fluxions, and of Prime and Ultimate Ratios;" but some exceptions that were taken to this production, even by the adherents of the fluxionary system, led him to publish more papers on the same subject.

The year 1738 found him defending Newton against an objection in the "Matho" of Andrew Baxter, the eminent Scottish metaphysician. In the following year he published his remarks on Leonard Euler's "Mechanica sive motus scientia analytice exposita," which had been published at Petropoli; a paper on Smith's "System of Optics," and another on Jurin's "Distinct and Indistinct Vision," published at the end of the last of these works. But the talents of Robins were not restricted to their proper sphere of natural philosophy and mathematics; he took a keen part in the angry and bitter politics of the day, and issued three pamphlets on the public affairs of the times, which created a great sensation.

The first of these was entitled "Observations on the present Convention with Spain;" the second was "A Narrative of what passed in the Common Hall, and the Citizens of London assembled for the Election of Lord Mayor;" and the third was an "Address to the Electors and other Free Subjects of Great Britain, occasioned by the late Succession; in which is contained a Particular Account of all our Negotiations with Spain, and its Treatment of us for above ten years past."

These pamphlets were all anonymous; and the first and last were so pungent that they were currently believed to be the production of Mr. Pulteney, who was then the active opponent of Sir Robert Walpole, and when the latter was ultimately defeated by the opposition, Robins was actually chosen secretary to the committee of the House of Commons appointed to examine into the conduct of that minister!

In 1742 he published his "New Principles of Gunnery," a work of which an account was given by himself in the *Philosophical Magazine* for the same year. In this book he concludes, from experiments he had made, that the force of gunpowder, at the instant of its explosion, is the same with that of an elastic fluid of a thousand times the density of common air, and that the elasticity of this fluid is proportional to its density, and in illustration proposes the following problem, which refers, of course, to *round* shot:—

"The dimensions of any piece of artillery, the weight of its ball, and the quantity of its charge being given, to determine the velocity which the shot will acquire from the explosion, supposing the elasticity or force of the powder at the first instant of firing to be given." In the solution of this important problem he assumes the two following principles:—

"1. That the action of the powder ceases as soon as it is out of the piece.

"2. That all the powder of the charge is fired, and converted into an elastic fluid, before the shot is sensibly moved from its place.

"These assumptions, and the conclusions above mentioned, make the action of fired gunpowder to be entirely similar to that of air condensed a thousand times, and from thence it will not be difficult to determine the velocity of the shot." Robins also gave an ingenious method of determining by experiments the velocity with which any shot moves at any distance of the piece it may be discharged from, by the adoption of a pendulum, a description of which would occupy too much space. By this he ascertained that the velocity of the common cannon-ball was 1,641 feet per second, when fired point blank. His work also combined an introductory history of modern fortification, with the invention of gunpowder, and the whole theory of gunnery.

In consequence of a paper having been published in the *Philosophical Transactions* against some of his opinions, he was led to submit to that learned body several treatises on the resistance of the air, and to exhibit the experiments on which they were founded, in the years 1746 and 1747. For this he was presented with the gold medal of Sir Godfrey Copley. When Lord Anson returned from his voyage round the world, the Rev. Richard Walter, chaplain of the *Centurion*, had proceeded to draw up a history of the expedition, but it was deemed advisable to have the whole rewritten by Robins. It appeared in 1748 with Mr. Walter's name on the title-page. The work went, however, through several editions, and the fifth was corrected by Robins himself in 1749.

In the same year he published in London "An Apology" for the defeat of the King's troops by the Highlanders under Prince Charles Edward at Prestonpans; and this paper formed a preface to "The Report of the Proceedings and Opinion of the Board of General Officers on the Examination into the Conduct of Lieutenant-General Sir John Cope."

Through the influence of Lord Anson opportunities were afforded him of making further experiments on his favourite subject of gunnery and all warlike projectiles; and through the same kind influence he procured for the Royal Observatory at Greenwich a second mural quadrant and other instruments. The services of Mr. Robins in science and politics had now become so prominent and so numerous, and his general reputation was so high, that the ministry of George II. became desirous of bestowing upon him some lucrative appointment. It was accordingly put in his option whether he would go to Paris as one of the government commissioners for adjusting the then vexed question of the limits of Acadia (the name originally given by the French to Nova Scotia and New Brunswick, and, indeed, to the whole of the North American Continent from the 40th to the 46th parallel), or to be the Engineer-General to the East India Company, the ruinous condition of whose forts required an able engineer to put them in a state of defence; and the somewhat military predilection of Robins, fatally for himself, induced him to prefer the latter. A regular corps of military engineers did not at that time exist in Britain, though officers termed civil engineers had occasionally been attached to the Ordnance Department from 1627, when the name of Thomas Rudd first appears on the list; and the first colonel-commandant appears in 1802.

Provided with a complete set of astronomical and other instruments for making scientific observations and experiments in the East, then a remote land and but little known to us, Robins, full of enthusiasm and ardour, sailed from London on Christmas Day, 1749, and after a hazardous and rough voyage he landed at Madras on the 13th of July, 1750. There he immediately set about the preparation of plans for the complete repair of Fort St. George, and Madras, which had been taken by the French in 1744, and had just been restored to us by the peace of Aix-la-Chapelle. The constitution of Robins was totally unsuited to the climate. In September he was attacked by fever, and though he recovered partially from its effects, he was unable to work or study, and fell into a languishing condition, which continued until the 29th of July, 1751, when this eminent English philosopher expired: thus he had only gone to India to find a grave in the Carnatic in the forty-fourth year of his age.

By his will he bequeathed the publication of his mathematical works to his friends Dr. James Wilson and Martin Folkes, and they published them in three vols. octavo, in 1761. His "New Principles of Gunnery" was translated into several languages; and they appeared in German from the pen of the illustrious Leonard Euler, accompanied by a copious commentary. This work was afterwards translated into English in 1779 by Mr. Hugh Brown. Besides the books already referred to, Benjamin Robins wrote a paper on the height to which rockets will ascend, which appeared among the *Philosophical Transactions* for 1749.

TECHNICAL DRAWING.—LXXII.

DRAWING FOR BRICKLAYERS.

PLAIN BRICK ARCHES.

PLAIN or rough arches are those in which none of the bricks are rubbed to suit the splay. Hence the joints which are quite close to each other at the intrados, are necessarily wider towards the extrados of the curve.

When the radius of curvature of a brick arch is small—that is to say, when it is under or not exceeding three or four feet—the best arrangement is to build two or more four-inch concentric brick arches over each other until the whole necessary thickness is obtained: each of these successive rings being built as an independent arch, without attempting to bond the upper or larger arch of any two into that which is immediately below it.

Fig. 588 represents a part of a semi-circular arch of this description supposed to have a span of 6 feet, and consequently a radius of curvature of 3 feet, and consisting of four concentric four-inch-thick arches combined into one arch of two bricks in thickness.

The bond of brickwork used in any arch is always judged by the appearance which it exhibits to the eye of the spectator looking up towards the intrados or lower surface of the arch. Hence in the present illustration, since all the bricks used, if so viewed, would have the appearance of stretchers, the whole arch is said to be built with stretchers, or in "stretching bond," being composed entirely of whole bricks laid as stretchers, excepting only at the two extremities of the arch, where each alternate voussoir is a bat or half-brick, without introducing which bricks composing a four-inch arch could not be properly bonded together.

The reason for building an arch of small radius with a series of four-inch rings, and without attempting to bond the successive parts into each other, is sufficiently obvious. The joints of such an arch diverge so very rapidly from the intrados outwards, that if it were built otherwise the brickwork would not be sufficiently compact, for at the upper part of the arch the bricks would be separated to an extraordinary and inconvenient degree. In some cases, headers—*i.e.*, whole-length bricks—are inserted at certain distances—that is, where three or four or more bricks of the inner ring cut in with four, five, or more bricks of the outer ring.

Fig. 589 shows the unfavourable effect which would be produced by building an arch of a small radius in the manner just alluded to. From this it will be seen that if the span of the arch were 3 feet, the external spaces between the bricks of a

two-brick-thick arch would be $2\frac{1}{2}$ inches. These joints, if filled entirely with mortar, would be prejudicial to the solidity of the work; and if filled with harder materials, such as pieces of stone, slate, or fragments of brick, the arch would have a motley and unseemly appearance.

It must be pointed out to the student that although the bricks in rough arches are said to radiate, it is their *centre lines* which do so, not their sides; the ends of the bricks are parallelograms placed on their narrow ends, and it will be readily seen that their sides could not converge to the centre. This cannot be clearly represented in Fig. 588, and therefore a few bricks are drawn on an enlarged scale in Fig. 590.

To draw a rough arch, having described the two arcs between which the ring of brickwork is to be contained, set off on the *inner* arc the true widths of the edge of the bricks of which the arch is to be composed, as *a, b, c, d;* find the middle of each of these spaces, as *e, f, g;* and through these draw lines converging to the centre from which the arcs are struck; then the sides of the bricks, *a k, b l,* etc., will be parallel to *e h, f i, g j,* etc.

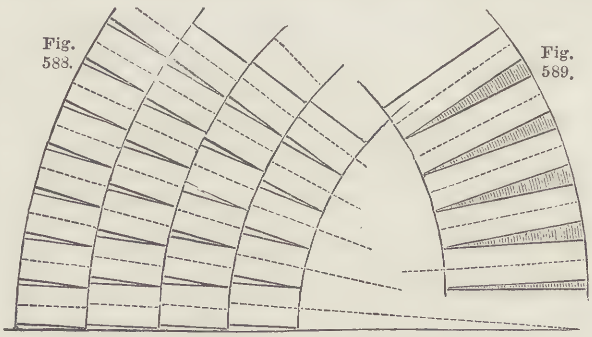


Fig. 588. Fig. 589.

In drawing gauged arches, the thickness of the separate bricks are set off on the *outer* arc, and from the divisions lines are drawn to the centre; the wedge form is thus given to the bricks, the inner end becoming narrower than the outer.

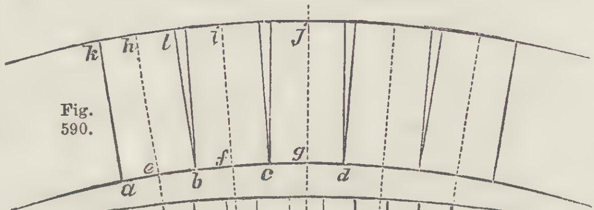


Fig. 590.

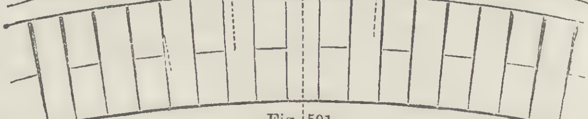


Fig. 591.

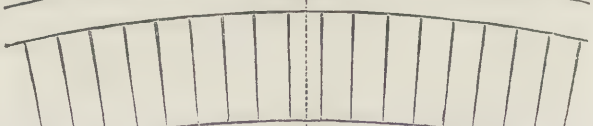


Fig. 592.

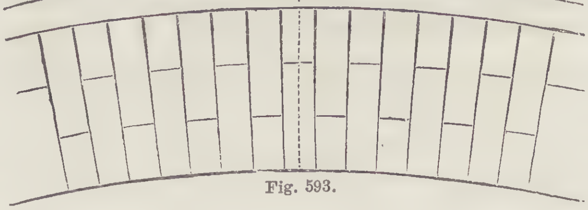


Fig. 593.

As the radius of the curvature of an arch increases, the joints diverge less rapidly, so that the use of nine-inch arches formed with heading bricks ceases to be objectionable.

For example, in a semi-circular nine-inch arch of 12 feet span (whose radius of curvature is of course 6 feet) the radius of the curve of the intrados is to its radius at the extrados as 6 feet to 6 feet 9 inches, or as 1 to $1\frac{1}{8}$. Hence the joints at the upper part of the curves will not exceed one-eighth part of the width of an arch-brick, or about five-sixteenths of an inch, which is neither inconvenient nor unseemly. If the radius of curvature be greater than 6 feet, the width of joint at the extrados of a nine-inch arch will be further diminished, so that in a semi-circular arch of 18 feet span it will scarcely amount to so much as one-fifth of an inch.

A nine-inch brick arch may be built according to three different methods—

1. The bricks composing the voussoirs may consist partly of headers and partly of stretchers, built according to Flemish bond. Fig. 591 represents the end elevation or section of part of an arch of this description, supposed to have a radius of curvature of 9 feet.

2. The bricks composing the voussoirs of a nine-inch arch may consist of headers and stretchers built according to English bond. In this case the extremities of the arch have the same appearance as in the former arrangement, which is likewise a correct section of this method. But the appearance of the brickwork of the intrados of this arch is different, being similar to common English bond in the face of the wall.

3. The bricks composing the voussoirs of a nine-inch arch of the same span and curve may be laid all heading bond, so that the transverse section of the body of the arch will everywhere be that represented in Fig. 592.

In an arch of this description no false headers are used, nor are stretchers used anywhere, excepting at the extremities of the arch, where they are introduced in alternate voussoirs for the sake of breaking the bond, the same being done in the face of a wall of this description.

Hence in a nine-inch arch built all in heading bond the section is as in Fig. 592, but the end elevation is the same as that of an arch of equal thickness built according to Flemish or English bond (see Fig. 591).

OF PLAIN ARCHES ONE BRICK AND A HALF IN THICKNESS.

In this case, if the radius of the curvature do not exceed three or four feet, such arches would of course be built in three concentric four-inch arches, according to the rule already laid down. In arches, however, of greater radius, such as from six to eight feet, the usual method is to build the voussoirs in alternate courses of headers surmounted by stretchers, and stretchers surmounted by headers from one side of the arch to the other.

Fig. 593 represents this arrangement, which is not only an end elevation, but a correct section of the arch throughout.

OF PLAIN ARCHES, AS APPLIED TO COMMON BRICK BUILDINGS.

The plain or rough arches used in common buildings are generally concealed from view. They are applied under the following circumstances:—

1. To cover the aperture of an external door or of a window in addition to the ornamental arch, which is generally a mere shell, as has already been explained.

When the arch of an external door or of a window is a semicircle or segment, the rough internal arch follows the same form, and no woodwork is used in aid of such an arch.

But when the ornamental arch of an external door or of a window is a straight or flat arch, pieces of timber, called *lintels*, are laid over the remainder of the aperture in rear of the ornamental arch, and in the internal doors of a building these lintels cover the whole space with a bearing of about 1 foot or 18 inches at each end.

In this case a rough arch is also usually thrown over the aperture above the said lintels, in order to relieve them of their weight of the superincumbent brickwork.

The annexed cut (Fig. 594), repeated from "Building Construction," represents the mode in which such rough arches should be formed in aid of a lintel. The intermediate space between the bottom of the arch and the woodwork is filled with bricks and bats cut to the curve and laid in mortar.

2. Rough arches are used for fireplaces.

In this case a bar of iron from $\frac{1}{2}$ to $\frac{3}{4}$ inch thick, and usually not less than 4 inches wide, is prepared beforehand suited to the form of the arch, and extending across the chimney-breast from one side to the other, so that it comprehends the width, not only

of the proposed arch, but also of the piers on each side or of part of them.

Upon this bar, the ends of which are turned back in contrary directions, and which is technically called a *turning-bar*, the arch is built, which bar, however, is not removed like common centering, but remains permanently in the same place in aid of the arch.

3. Rough arches are used beneath the hearths of fireplaces.

It has been explained in "Building Construction" that no woodwork is admissible below a fireplace, and that joists extending in that direction are framed into a transverse piece of timber called the *trimmer*, which is usually two feet distant from the chimney-breast, in buildings of importance. Between this trimmer and the bottom of the fireplace a four-inch segment brick arch, rather less than a quadrant, is constructed, which rests on one side against the upper part of the trimmer; and this is the vertex of the curve. On the other side, which is on a

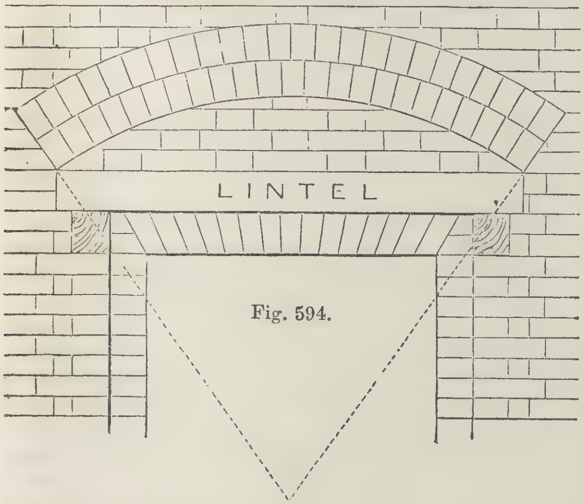


Fig. 594.

level with the bottom of the trimmer, it springs with a skewback from the wall; the space between the top of the arch and the under surface of the hearthstone is filled in with brickwork. This arch has been illustrated in Lessons on "Building Construction" (TECHNICAL EDUCATOR, Vol. II., page 5).

4. Rough arches are used beneath the entrances of all buildings having an area to the basement storey. In this case a leaning arch is used, which on one side abuts against the area wall, while on the other it leans against the wall of the building. Above this arch, and extending partly across the area, and on the same level with the pavement, or sometimes one step above it, large flag-stones are laid; beyond which a flight of two or three steps, at least, usually leads from that level to the entrance-door of the building. Fig. 587 (page 384) exemplifies this arrangement. These arches are technically termed *bridgeways*.

PHOTOGRAPHY.—XI.

By J. C. LEAKE.

PHOTO-LITHOGRAPHY.

ALTHOUGH the process of printing in carbon or pigments, described in our last paper, has to some extent superseded the photo-lithographic process, the latter is of so important a character, especially when copies of maps or line-drawings are required, that a knowledge of the process is essential to the practical photographer. We will therefore devote this paper to the consideration of the subject, merely observing that, beside the photographic part of the process, it is desirable that the operator should possess some knowledge of the system of ordinary lithographic printing. An ordinary lithographic press will be required, with stones, inking-rollers, and suitable ink.

One of the most important points, in order to ensure success in photo-lithographic work, is the production of a negative of exceeding density and clearness. The lines must be perfectly sharp and transparent, the smallest trace of fog being fatal to anything like clear delineation. In order to ensure these conditions some variations from the ordinary photographic processes are required, and these we will proceed to describe. The collodion should be one which adheres well to the glass, and should be rather old. Unless it works perfectly clear in the shades it should be mixed with a little dilute tincture of iodine, made by dissolving iodine in pure alcohol. Enough of this may be added to bring the mixture to a dark sherry colour. It must also be allowed plenty of time to settle, and be perfectly clear. The nitrate bath should be of full strength—from thirty-five to forty grains of silver to the ounce, slightly acid, and perfectly clear and clean. The exposure should be enough to secure a tolerably rapid development, as unless the image can be obtained upon one application of the developer there is danger of fogging the lines and destroying their sharpness. The best developing solution is a fifteen-grain solution of sulphate of iron with the same proportion of acetic acid, to which is added as much alcohol as may be needed, in order to make it flow evenly over the plate. As soon as the lines of the drawing are visible the plate should be well washed and slightly intensified in the ordinary way with pyrogallic acid solution and nitrate of silver.

The negative should then be fixed with hyposulphite of soda, and thoroughly washed. It should now be carefully examined in order to ascertain that the image is sharp, well-defined, and free from fog. The lines should be perfectly sharp, and without the slightest trace of deposit. This being the case, the negative may be intensified by pouring over the surface a saturated solution of bichloride of mercury, washing, and afterwards darkening with a very dilute solution of hyposulphite of soda. Should the negative not be sufficiently intense this operation may be repeated, when the film should be very thoroughly washed in order to remove all trace of the hyposulphite.

It should be borne in mind that for copying drawings and maps by this process the negative must be perfectly opaque in the lights and as perfectly transparent in the shadows, as upon these two conditions the whole success of the work will depend. The negative should be left unvarnished. The next operation is the preparation of the photo-lithographic paper. For this purpose the ordinary Saxe paper will answer very well, as will also that known as bank-post. The gelatine is prepared as follows:—Take three ounces of fine gelatine, and dissolve in forty ounces of hot water. While still hot filter through warm wet flannel or fine muslin. For use the gelatine must be kept in a fluid state by means of heat. If used in a dish the first must be placed in a second and larger vessel, filled with hot water. The surface of the fluid gelatine should be skimmed with a slip of paper, and the sheets to be coated, after being cut to the requisite size, be floated upon the surface, taking the utmost care to avoid air-bubbles. When coated the paper may be suspended until dry. Another and excellent plan is to procure a sheet of glass of the required size, and having immersed it in warm water, to place upon it the sheet of paper to be coated, and which has also been damped in water of the same temperature. The sheet should then be pressed down evenly upon the glass by means of the india-rubber "squeeze" mentioned in our last paper on carbon printing, and the superfluous moisture removed from its surface. While still warm the melted gelatine may be poured over the surface, and the sheet coated by tilting the plate precisely as if coating a plate with collodion. It should then be placed perfectly level upon a suitable stand, and allowed to set, which it will do in a few minutes.

The sheet may then be slipped off and suspended to dry. This is an excellent plan where a few sheets only are required, as a small quantity only of gelatine is employed, and there is little or no waste. Paper thus prepared resembles that which has been albumenised, as it is insensitive, and will keep an indefinite time in a dry drawer or box.

The sensitising of this paper is effected by immersing it in a saturated solution of bichromate of potash. It should remain in this for a few minutes, and after removal be thoroughly dried, when it will be ready for exposure to light under the negative. As we before remarked with respect to this part of the carbon process, it is well-nigh impossible to give any definite rule as to the time required, but with an average light about five or ten minutes will be necessary.

The next operation is that of inking the impression, and is performed as follows:—(For this purpose the lithographic press

will be required.) Take a clean polished lithographic stone, and charge it by means of the litho-roller with a smooth and perfectly even coating of litho-transfer ink. The thickness of the ink will cause a considerable variation in the result, and can only be determined by practical experience. The print should then be allowed to soak in cold water for about a quarter of an hour, when the excess of moisture should be blotted off, and the paper with the impressed image placed, gelatine side downwards, upon the inked stone. The whole may now be passed through the press in the usual manner, using rather less pressure than would be required in the ordinary process of lithographic printing. When removed from the stone the print will be found to have received a uniform coating of ink, and the more uniform this coating is the sharper and better will be the final result.

In order to remove the superfluous ink the print should be well soaked in cold water. A solution of gum-arabic should then be prepared of rather more than the average strength, and to this should be added a little weak solution of nitric acid. This mixture should be applied to the print with a soft sponge, when it will be found that the ink may be readily removed from all those portions of the surface upon which the light has not acted, while it will adhere tightly to those which have been exposed to its influence, thus leaving an impression in lithographic ink upon the surface of the paper. All that now remains to be effected is to thoroughly clean the lights by means of careful sponging with clean gum-water, after which the transfer print is complete, and may be laid by to dry. At this stage of the process the question of success or failure may easily be determined. If it should be found that the finer lines which lie close together, or the angles formed by the crossing of the lines are filled up with ink and are not quite sharp, clean, and well-defined, then there has probably been too much ink upon the stone; while if, on the other hand, the lines are clean and well defined, but wanting in vigour and in sufficient body to transfer themselves well to the stone, the defect will probably arise from the inking having been insufficient. This latter defect, however, is seldom met with in practice. The ink should leave the paper quite freely and easily as well as completely; and when this is not the case, and if there should remain upon what should be the unaltered portions of the film traces of ink in patches over the drawing, in all probability light has reached the paper either through a defective negative or from some carelessness during the process. It cannot be too strongly impressed upon the operator that the bichromated gelatine is exceedingly sensitive to light, and that in all processes wherein this substance is employed the utmost care must be exercised in order to protect it from any extraneous action. In fact, it should be as carefully shielded as a sensitive collodion plate. Should the lines appear broken, and betray an inclination to leave the paper, it is most likely that the exposure to light has been insufficient to completely alter the character of the gelatine, which is consequently still partially soluble. It frequently happens that, while the coarser lines are bold and vigorous, the finer ones are weak, ragged, and partially obliterated. This mostly arises from an imperfect negative. If the intensification has not been carefully performed, a very fine deposit, almost invisible except to the most careful observer, is formed in the finest lines, and this is quite sufficient to prevent a proper action upon the gelatine.

It may not be out of place here to remark that the process above described is not suited for the production of pictures in half tint, except the gradations are produced by lines or dots. For instance, a line-engraving or a manuscript may be perfectly reproduced; but an ordinary photograph would be utterly useless if copied by these means. Many attempts have been made in this direction, and some of the results have been most promising, but no process has, up to the present time, been uniformly successful. These remarks are not intended to deter the operator from experimenting in this direction, but simply to prevent his attempting to copy pictures which, from their unsuitability to the process, would probably lead to failure and disappointment.

In conclusion, we would observe that this process is based upon the fact that, while gelatine in its normal state—that is to say, unacted upon by light—is absorbent of water and soluble, it becomes after that action insoluble and non-absorbent. Thus after the exposure under a negative the print is wetted, and water is absorbed in all the unaltered portions, while those which have been exposed remain dry. The fatty ink employed is consequently resisted by the wetted parts of the surface, while it is retained by those which remain dry; thus forming the print which is transferred to the stone. There is often little or no relief in the impression, and the print is formed through this attraction and repulsion of the fatty ink alone.

We have not thought it necessary to describe the transfer of the print to the lithographic stone, as that is effected precisely as in the well-known lithographic printing process; but we should advise the operator to endeavour to see the transfer process performed before attempting to effect it for himself, as he would learn more in a few minutes from actual inspection than could possibly be acquired from mere written instructions, however elaborated.

MAP AND PLAN DRAWING.—III.

By C. C. King.

METHOD OF CONSTRUCTING CHARTS—THE WORK DONE ON SHORE—THE WORK DONE ON THE WATER—ABBREVIATIONS AND CONVENTIONALITIES USED IN DELINEATING CHARTS.

The careful construction of a map of a large territory, conducted as we have described, presupposes an advanced state of civilisation in the country thus delineated. Experienced workmen, a population not adverse to the survey, the assistance to be derived from government or civil authorities, are all essential to accurate work. The necessity for it must be recognised by the people, so that the different stations may remain undisturbed during the operations; and the necessity or value of such a map presupposes an area well populated and cultivated, and with an abundance of large towns and villages, the communications between which are numerous enough to render movement practicable and inspection of the details possible.

But beyond the limit of such countries, there is much to be discovered and mapped, which is useful and necessary to the inhabitants of the civilised districts. An accurate description of the coast-lines and land adjacent to the sea are requisite for the prosecution of commercial enterprises, as well as to enable vessels to move with confidence from point to point. For this purpose charts or hydrographical maps are constructed, and these rarely go beyond the immediate coast-lines of the islands or continents. In barbarous countries a survey beyond this limit would be practically impossible, not merely because of the opposition of the inhabitants, but more especially because of the uncultivated nature of the land rendering an extensive triangulation a matter of extreme difficulty, even if it were permitted by the natives, or if it were to the interest of the nations concerned in knowing the character of the country, to provide the means for carrying out the work. In these cases the coast is alone depicted, and the interior of the area either left a blank, as is usually done with the African continent, or if it cannot be approximately filled in by local information or even maps, which would be done in China or any semi-barbarous realm, some few points are determined by their latitude and longitude, and as much of the neighbourhood sketched in somewhat roughly as time and opportunity will permit.

The chart, however, to be useful and reliable must be carefully completed, as the information it has to give can be readily procured; and as moreover the value of a chart to a vessel depends entirely on the faithfulness of the representation of the coast itself, the accuracy of the soundings taken, and the exactness of the position of all the remarkable features given by their latitudes and longitudes, as well as their respective distances and relative bearings one from the other, must be accurately ascertained.

Chart-making is simply the extension of the land survey of a great country, such as we have imagined, to more distant parts, thus completing the delineation of the remainder of the earth's surface; only in these maps we deal with a bare outline of the foreign countries or an imperfect filling-in of the interior rather than with the careful, laborious delineation of every feature, physical or otherwise, which results from a measured base and a system of triangulation. Some knowledge of astronomy is absolutely required by the operators in this species of surveying, as the distances from one principal point to another can only be determined by their latitude and longitude if far apart.

Instruments have to be constantly adjusted or corrected by astronomical observations, and a rough practical acquaintance with the positions and movements of the heavenly bodies, and the causes leading to variations both of compasses and other instruments, is indispensable.

The construction of a chart, then, divides itself into two parts—first, the work done on shore; second, the work done on the sea. The former is a repetition of an ordinary survey as far as practicable—that is, a point is first astronomically fixed by its latitude and longitude, either by means of a sextant and the artificial horizon, or by means of a small transit instrument. The sextant is a metallic frame constructed in the form of a segment of a circle, the arc of which is graduated in 140 degrees. A movable arm, which is pivoted at the centre of the circle of which the instrument forms a part, extends to the graduated arc, and is capable of being retained in any given position by a clamping-screw. It is furnished at its upper or pivoted end with a mirror, accurately fixed by the maker so as to be always perpendicular to the plane in which the arm moves and parallel to the arm, thus partaking of its movement; and at its lower extremity on the arc it has a vernier for reading minutes and seconds of an angle measured, with a small motion-screw for careful adjustment, and a microscope for accurate observation. A telescope is fitted in a socket at one side of the instrument, and on the other side of the frame is fixed a small glass called the horizon-glass, the lower half of which is a mirror, and which is so adjusted that its plane is perpendicular to that of the sextant, and parallel to the movable arm when it is fixed at zero. Coloured glasses are provided, to be used in taking observations of the sun. In using it the telescope is screwed in, and while one of the two objects between which the angle is to be taken is viewed through the upper or transparent portion of the horizon-glass, the movable arm of the instrument is moved until the reflected image of the second object is thrown from the movable on to the fixed mirror, and the two objects made by a slight motion of the hand to coincide. The arm is then clamped, the exact coincidence of the objects determined by the small motion or "tangent" screw, and the reading, which is the angle between the two points, taken. The artificial horizon is a small flat iron vessel to contain mercury, and is protected from disturbance from wind or other causes, by a glass shade or cover. By it the altitude of the sun at any given time can be ascertained, the observer bringing the image of the sun reflected in the mercury, and seen through the unsilvered portion of the horizon-glass, in close juxtaposition with the image reflected on the movable mirror of the arm, and thence on the lower portion of the horizon-glass. It must be remarked whether the upper or lower limbs of the sun have been brought into contact, and having the time of observation noted down, the latitude can be determined by calculation.* The longitude is, of course, ascertained from the chronometer, by means of which the difference in the time at the station and at Greenwich can be ascertained. The transit instrument is only used in observations where time and opportunity are afforded for the work. It is simply a telescope mounted on a frame, which must be carefully adjusted in the plane of the meridian, and affords the means of obtaining the exact time at which certain planetary bodies cross the meridian, and their distance from the zenith. Thus the longitude can be obtained, or even, by arrangement, the latitude.

From the point thus determined a survey of as extensive a nature as possible would be made. A base-line, measured some few times to ensure approximate accuracy, would be fixed, and from it by triangulation the distances of the more prominent objects would be calculated; but as any materials at hand, such as a deal rod, or a "lead line" used in taking soundings, would be used to effect the measurement of the base, the most important part of any survey, the results arrived at would be only approximately true. The work done on shore, then, is a rough, generally hasty attempt at delineation by the ordinary principles of surveying, a theodolite being employed when practicable for measuring the angles, and in other cases the sextant.

The work done on the sea, which is the more important of the two divisions of the chart, obliges us to use different means of providing our data for calculation, though the application of these data is in principle the same as in a land survey. We are unable to measure any base upon the sea from which to determine the relative positions of our main points, and we have further to ascertain a new series of facts, that do not, of course, enter into our previous work—the depth of water, and the size and character of rocks or shoals which may be concealed beneath the surface of the sea, or be only apparent at certain times of tide.

The instruments required, therefore, are the chronometer to calculate longitude, and which is to be corrected by "lunar distances,"* or other astronomical observations, for its rate—that is, its variation from day to day, and its error of rate, or the error in that variation; the sextant, which has been described above; the ordinary mariner's compass for ascertaining magnetic bearings, which has to be corrected for its variation by taking the true bearing of the sun at noon, and then calculating the variation according to fixed laws; and lastly, the "sounding lead," a line twenty-five fathoms long, furnished with a long leaden weight hollowed at its base, so as to contain a little grease, to which sand or pebbles, showing the character of the sea-bottom, may adhere.

The method of procedure is the same as in a survey on shore. The surveying vessel anchored, and with its true place found by observation, forms the principal point to which all others are referred. A series of boats, each containing a sounding line and an officer for taking the observation, diverge in different directions from it, and at the requisite distances from the ship take angles between it and each other, thus forming a rough series of triangles, which should be as nearly as possible equilateral. These distances are ascertained in two ways: either by reading the angle subtended by the mast of the ship from the truck to the keel, and from prepared tables finding the base of the right-angled triangle, which is the distance required, or by calculating it from the velocity with which sound is known to travel. For this purpose those boats which proceed on a course as nearly as possible at right angles to the direction of the wind are selected, and guns are fired from the vessel to give the necessary data, pocket chronometers or stop-watches being employed to determine with all possible accuracy the intervals of time that elapse between the moment when the flash of the gun is seen and the sound of the report is heard by the observer. If the boats be large enough, one or more may carry small guns, which, if fired with a high elevation with shot, will give a report that can be heard a considerable distance; and thus a series of results may be obtained, which will give a satisfactory and tolerably correct mean. If the weather be calm, and the area to be examined extensive, beacons constructed of small barrels, with a staff and distinguishing flag, may be anchored at convenient points; and these will form intermediate stations of greater comparative accuracy than can be obtained from the boat, influenced as it would be by tide or wind. Thus the data on which the triangles are constructed are given by the position of the ship, the true "bearing" of the boats, and the distance calculated by sound; while the nature of the bottom is arrived at by a series of soundings taken on any given "bearing" at intervals of about ten minutes, when also any alteration in the character of the material composing the bottom is carefully noted.

Thus the area of the shoal, if it be one, is carefully marked out, and the same operations are carried on in the case of a bay, a river, or an inlet; the only difference being that the observations taken by the boats are corrected, and the number of intermediate points increased, by taking the magnetic bearings of any number of the most striking points on the coast (which may be further corrected by astronomical observation), and where also observers may be landed to take a further series of angles, and sketch the nature and form of the coast-line. Beacons are erected at these places when practicable, and even rocks may have white marks painted on them for the con-

* It must be remembered, in using the artificial horizon, that the angle taken is double the true angle of elevation of the sun above the horizon, owing to the refraction of the mercury in the vessel, and that hence half the angle measured by the sextant will give the true elevation.

* The "lunar distance" is that between the moon and sun, or any fixed star or planet lying nearly in its path. When this is determined, the longitude can be found by calculation.

venience of being clearly seen from the starting-point (the ship), and thus promote accuracy of observation from it. A valuable amount of information may be obtained from the ship itself, as the rise and fall of tide, velocity of current, etc., and the direction of mountain-peaks far inland could be observed from the mast-head.

The information provided by a chart, therefore, is chiefly of a nautical character. At the best the delineation of the coast-line, with such inaccurate and untrustworthy means as can alone be employed, can be but approximately correct, and only the positions of the most remarkable features, as well as the variation in the depth of the water, can be deemed really accurate.

Even less complete nautical surveys are undertaken occasionally, as, for example, the examination of a coast or harbour by a hostile fleet of vessels, where the distances are determined

Current — + Rock with one fathom of water.

Flood tide (direction of) — Rock nearly awash.

Ebb tide (do.) — Sand that dries, with depth of water at high water.

Kn. Knots or nautical miles — Mud that dries, with depth of water at high water.

Anchorage for large vessels......... Inside this line less than one fathom

Do. for small vessels .. .. .. Inside this line less than two fathoms

Do. for coasters ... ... Inside this line less than three fathoms

H.W. High water .—.—.—. Inside this line less than four fathoms

L.W. Low water ..—..—..—.. Inside this line less than five fathoms

At low water.

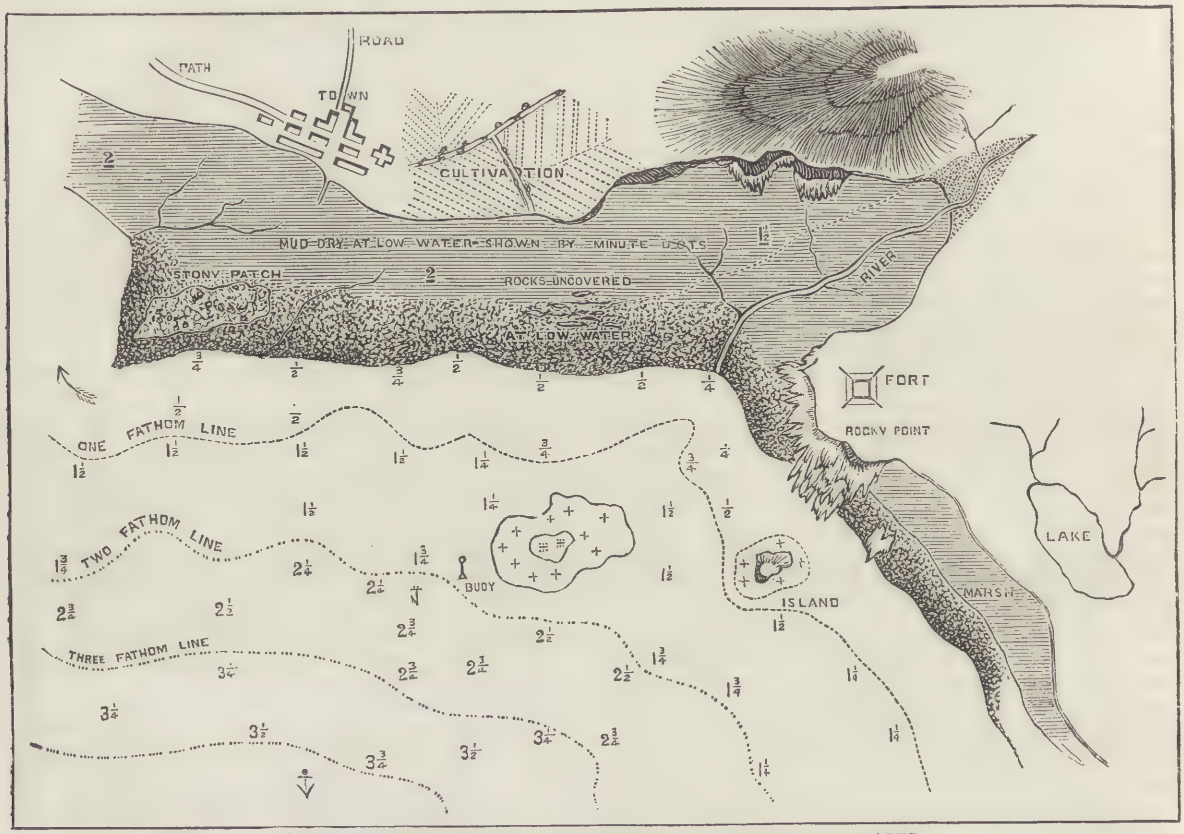


Fig. 9.—DIAGRAM SHOWING THE METHOD OF DELINEATING CHARTS.

by the intervals between the ships, or the measurement between any two observed points or times in the ship's course, by means of the log, which gives the rate at which the vessel has travelled, and the chronometer, which indicates the number of hours taken in traversing that distance.

The information afforded by a chart is first the general outline of the coast, with the positions of the prominent natural features inland, which serve, so to speak, as landmarks; and secondly, the variations in the depths of water, and the nature of the beaches or the sea-bottom. The latter is indicated by abbreviations of the actual name, as—

b,	blue.	*h*,	hard.	*s*,	sand.
bk,	black.	*m*,	mud.	*sf*,	soft.
brk,	broken.	*oz*,	ooze.	*sh*,	shells.
c,	coarse.	*oy*,	oysters.	*sm*,	small.
ch,	chalk.	*p*,	pale.	*sp*,	speckled.
cl,	clay.	*r*,	rocky.	*st*,	stones.
g,	gravel.	*rd*,	red.	*w*,	white.
gn,	green.	*rot*,	rotten.	*wd*,	weeds.

The other conventionalities used in the description of charts are shown as follows:—

Sandy beach — $\frac{\cdot}{5}$ No bottom at this depth.

Gravelly beach — *fm.* fathoms.

Stony beach — *ft.* feet.

F. I. R. Near a lighthouse is fixed, intermittent, or revolving light — *spr.* springs.

B. C. R. W. Near a buoy is black, chequered, red, or white. — *np.* neap-tides.

The north point is marked in several places on the chart, with the variations of the compass. The value of the lines marking the number of fathoms is especially great in certain cases, as, for instance, in the English Channel. So carefully are they shown in charts of this portion of the sea, that navigators, even if they cannot fix their position by observation, owing to atmospheric disturbance, imperfect instruments, or other causes, can ascertain when they are entering it by sounding; and as the lines of equal soundings are definitely marked from coast to coast, they can approximately determine their place on the chart by knowing between which lines they are then passing.

SHIP-BUILDING.—XV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

METHODS OF SHEATHING IRON SHIPS.

PROPOSALS were made many years ago to cover the bottoms of iron ships with wood planking, and to nail upon that foundation copper or other metal sheathing in order to prevent fouling and the consequent loss of speed. The plan was not, however, used until recently, the first example of a sheathed iron ship being found, we believe, in the swift ocean-cruiser, *Inconstant*, designed for the Royal Navy about ten years ago. In this case it was desired to unite very high speed with a very powerful armament, and with the power of keeping the sea for long periods without loss of speed. To reach the high speed, very powerful engines and a very finely-formed ship were required, both of which features tended to produce extremely severe strains that could only be borne without injury by an iron hull. On the other hand, to secure a bottom that should continue clean for long periods, it seemed desirable to use copper sheathing; consequently the experiment was tried, and so far the results have been satisfactory. Several other vessels, including two iron-clads, have been since constructed for the navy on similar plans, but we are not aware that any iron merchant ships have yet been sheathed with copper, the expense of such a mode of construction having probably prevented its adoption. Zinc sheathing has been tried in a few cases both in the Royal Navy and in the mercantile marine, and is preferred to copper by some ship-builders for reasons which will appear hereafter.

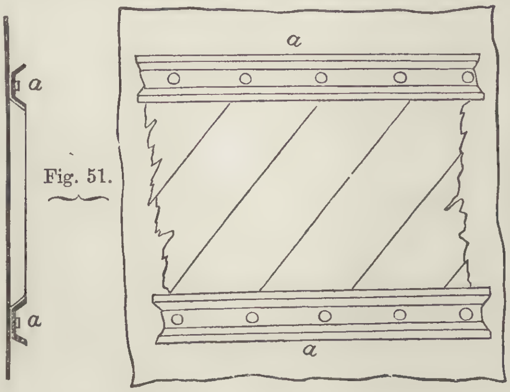


Fig. 51.

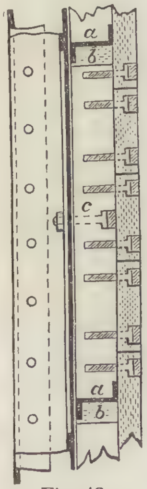


Fig. 48.

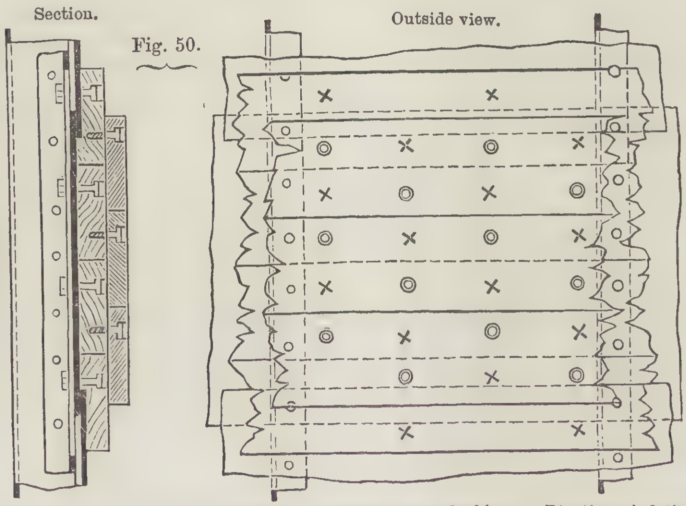


Fig. 50.

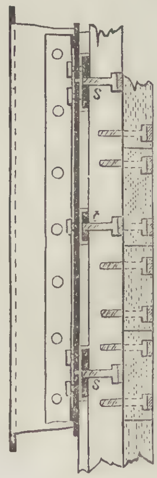


Fig. 49.

Refs. to Fig. 50.—⊙ Butts of outer planking; × Butts of inner planking; o Riveting of plating to frames.

If a piece of copper and a piece of iron are immersed in salt water, and metallic contact is made between them in a manner resembling that made between the two plates of a galvanic battery, galvanic action will be set up and the iron will waste. Hence it is necessary to use great precautions when iron ships are sheathed with copper, in order to prevent galvanic action and the consequent deterioration of the iron hull. Allusion has already been made to the similar caution required in the construction of composite ships, so that we need not dwell upon the matter now, simply stating that direct metallic contact, as well as indirect metallic connection, between the copper sheathing and the iron hull should be avoided as much as possible, and every means taken to make the wood planking and its fastenings sound and tight, in order that the skin plating may be kept dry. These are two most important conditions which ought never to be lost sight of in building vessels of this class.

Without further preface we will proceed to notice two or three plans for sheathing iron ships with copper, taking first one proposed by Mr. Grantham many years ago. The planking is wrought in two thicknesses (see Fig. 48), the inner thickness being fitted directly upon the skin-plating, and the outer thickness being fastened to the inner by copper or metal screw-bolts which do not pass entirely through the inner planks. The inner thickness is secured without using many (if any) bolts; a fact to which Mr. Grantham attributes much importance. Outside the skin-plating Z-shaped iron frames (a, a) are worked longitudinally at frequent intervals; the inner planks are worked in short lengths between these frames, and wedges (b, b) are driven in over the ends to secure the planks. This wedging arrangement has been much objected to by many practical ship-builders, who consider it to afford an insufficient attachment for planks to which all the outer planking has to be secured; and there seems much force in the objection. It is only right, however, to add that Mr. Grantham provides for the use of a limited number of bolts in some cases, these being placed mid-way between the external frames (like c in the figure), and secured by nuts and screws to the skin-plating. Where the main framing is transverse (as in Fig. 48), Mr. Grantham proposes to place the external frames longitudinally; but where the main frames are longitudinal, he would place the outside frames transversely. The principle is the same in both cases, and the whole arrangement for securing the inner layer of planking is based upon the belief that iron bolt-fastening should be avoided as much as possible, because of the probably rapid deterioration of such bolts if the planking became saturated, and galvanic action should be set up between them and the copper sheathing.

To some extent this view is doubtless correct, as experience with composite ships—having their planking in one thickness and fastened with iron bolts—proves. In such cases the large area of the copper sheathing has its action concentrated upon the comparatively small areas of the bolt-heads or shanks, and as a consequence their deterioration is often rapid. But the case is widely different when two thicknesses of planking are used and carefully fastened in the manner explained in page 277;

the iron bolts of the inner thickness then being comparatively distant from the copper sheathing, and not nearly so likely to suffer by galvanic action or other causes. This distinction between the use of one and two thicknesses of planking Mr. Grantham does not appear to recognise sufficiently in his arguments against bolt-fastenings, nor does he note the much greater strength to resist *working* in the sheathed ship. On his plan, too, the planking cannot be regarded as adding much, if anything, to the strength of the ship, because of its comparatively slight attachment to the hull. Of course, the iron hull in itself can be easily made so strong as to require no such assistance; but on the other hand, by arranging and fastening the planking differently, it may be made to help the hull proper considerably, while forming an equally efficient foundation for the copper sheathing, as will be shown almost immediately. It should be added that Mr. Grantham also proposed to use brass stems and stern-posts in sheathed ships, a plan which has been frequently conformed to, when other modes of securing the planking have been followed.

Fig. 49 shows in section the plan of sheathing first used in the Government service. The skin-plating is worked directly upon the frames, no liners being required, and the flush edge-joints are secured by external strips (*s*, *s*). These are made much thicker than the plating, in order to permit the ends of the iron bolts, forming the principal fastenings of the inner planking, to be screwed *into*, but not *through* them. Midway between the edge-strips other thick strips (*t*) are worked, in order to receive the screwed ends of additional fastenings; and the spaces between the strips are filled up with thin planks secured by marine glue, so as to form a flush surface, and avoid any necessity for scoring the inner layer of planking. This is worked transversely, the lengths of the planks extending from the keel towards the gunwale, and the butts being screw-bolted to strips fitted for the purpose. By these arrangements the inner planks are strongly secured to the hull, and yet the bolts leave the skin-plating itself unpierced, so that in case of an accident which stripped off the planking the skin would still remain water-tight. The outside planks are worked longitudinally, and secured by metal screw-bolts kept clear of the iron fastenings, and passing about two-thirds through the inner planks.

This plan is therefore, at least, as efficient as Mr. Grantham's in preventing metallic connection between the copper sheathing and the iron hull; and it makes a stronger and more intimate connection between the hull and the planking. It involves, however, the necessity for great care and considerable expense in order to secure thoroughly good workmanship in connection with the fastenings of the inside planking. For example, in drilling the holes in the strips caution is needed to prevent them from passing *through* the strips, and no less care is required to ensure exactitude in boring the bolt-holes in the planks so that the bolts may be properly hove up. For these and other reasons the simpler plan illustrated by Fig. 50 has been used in the later sheathed ships of the Royal Navy.

The plating is here worked on the common in-and-out plan. Both thicknesses of planking are worked longitudinally, the edges of strakes being brought upon the centre lines of strakes overlying or underlying them. The inner thickness is fastened by iron bolts screwed through holes tapped in the plating, and farther secured by nuts hove up inside the iron skin. Consequently damage to the bottom, even if it were to strip off the planking, would not be likely to cause a leak; because the screwed ends of the bolts would most probably remain in and fill the holes in the plating. And, in addition, if the nuts were broken off or removed by any mischance, the bolts would still have a hold on the plating.

The outer thickness is fastened in the usual manner by metal screw-bolts passing partially through the inner planks, and a reference to the outside view in Fig. 50 will show how these bolts are kept clear of the iron fastenings. A merely casual glance at the arrangement may lead to the opinion that this method of securing the inner layer of planking unduly weakens the skin-plating, and that it is consequently inferior in this respect to the preceding plans. But on a closer examination it will be remarked that the iron bolts are spaced further apart, on any transverse section of the plating, than the rivets are which attach the plating to the frames; so that the unavoidably weakened sections in wake of the latter still continue to be the places where fracture is most likely to take place, and no real loss of strength results from drilling the holes for the bolts. Moreover, it will be obvious that the two layers of wood planking form a skin possessing in itself considerable strength, and so efficiently connected to the iron hull as to be capable of lending it aid to a greater extent than can the planking on either of the other plans. Much has yet to be learnt respecting the limits within which wood and iron so combined may be considered to act jointly; but there is reason to believe that under such strains as may be considered of ordinary occurrence, the wood skin of a ship sheathed as in Fig. 50 would lend valuable aid to the iron plating; and on the other hand, the plating would probably do much to prevent that working in the wake of the fastenings which is likely to take place in the skin-planking of wood and composite ships. The plating of sheathed ships is usually somewhat thinner than that of unsheathed iron ships of equal size; but the difference in thickness is not great, and the reduction actually made is regulated rather by consideration of the fact that the planking has to be fastened to the plates, than by a regard to structural strength.

At the outset it was stated that the prime object of the wood planking was the prevention of metallic contact or connection between the copper and the iron hull; but one indirect advantage gained by the thick coating of wood is the greater strength of the bottom to resist penetration by blows which would break through unsheathed plating. Double bottoms are consequently not so necessary in sheathed ships as in ordinary iron vessels, and they have not been constructed in most cases. However the planking may be arranged, care is required in caulking both thicknesses, making the bolts water-tight, and coating the faying surfaces with some water-tight material, such as marine glue; in short, no means should be left untried to prevent the iron plates and bolts from becoming damp, and wasting by rusting or galvanic action.

There have been many other proposals for sheathing iron ships with copper, to which reference might be made did space permit. One only can be mentioned, which was put forward by Mr. McLaine, and was most novel in conception. His plan was to build the iron ship with frames *outside* the skin instead of inside; then to bolt wood timbers to the frame angle-irons, and upon these timbers to fasten wood planking in combination with a wood keel, stem and stern-post. In fact, his method may be shortly summed up as a combination of the timbers, planking, keel, etc., of a wood ship, with the skin, decks, bulkheads, etc., of an iron ship, the connection between the two being made by the means described. Some high authorities expressed favourable opinions respecting this plan, but it has not, we believe, ever been practically applied, and it would certainly lead to both costly and heavy ships.

Attention must next be turned to zinc sheathing for iron ships, which has been strongly advocated by many persons in preference to copper. When zinc and iron are immersed in salt water, and the circuit completed by metallic connection between the two, galvanic action is set up, the zinc wasting while the iron remains unoxidised. Consequently no injury to the hull need be anticipated from sheathing an iron ship with zinc; and in this respect such sheathing is doubtless superior to copper. It is also much cheaper—about one-third the price of copper; but the question of its anti-fouling qualities as compared with copper is not thoroughly settled, and this is a most important one. Copper when immersed in sea-water becomes oxidised on the surface, and this oxide being soluble is slowly and gradually washed off, so preventing the attachment of marine plants and animals that would otherwise cause foulness of bottom. This process, termed "exfoliation," is often so very gradual that the copper sheets last for very many years under water, and yet keep the bottom of the ship clean. Zinc, on the contrary, when used to sheathe the bottoms of wood ships, does not exfoliate like copper, the oxide formed upon its surface not being readily soluble, and consequently it does not keep the bottoms so clean; still its cheapness leads to its frequent use on wood merchant ships, and under these circumstances it lasts for a long time. To render zinc sheathing more efficient against fouling, it is necessary to establish galvanic action by bringing it into contact or connection with iron or copper bolts in wood ships; or in the case of sheathed ships allowing it to have some contact with the iron plating or other pieces of the hull. Its oxidation then becomes much more rapid, and its anti-fouling properties are increased; but on the other hand it wastes much more rapidly than before, and requires to be sooner renewed. The larger the

surface of zinc and iron in contact the more rapid is the waste of the zinc; and so far the chief difficulties attendant upon the use of zinc sheathing for iron ships have been caused by a want of certainty in our knowledge respecting the regulation of the amount of contact between the two metals. This regulation should be such as to give an amount of contact just sufficient to keep the surface of the zinc clean, so that it should not waste too rapidly (because the zinc might then require to be renewed so frequently as to more than do away with its advantage in first cost as compared with copper); and it should provide the contact in such a fashion as to secure a uniform wasting over the whole surface of the zinc. Experience may help us to decide how these desiderata may be obtained; but at present they do not seem to have been secured, and consequently copper sheathing is preferred.

Passing from these general considerations, we will notice a few of the methods proposed for sheathing iron ships with zinc. One of the simplest plans tried consisted in securing sheets of zinc outside the plating by means of light iron rods riveted around the edges of the sheets, and a few small studs placed near the centres. This appears, however, to have made the surfaces of contact between the iron and the zinc much too great, and as a consequence the latter wasted rapidly, leaving the iron plates exposed.

Mr. Daft's plan for zinc-sheathing has attracted much attention, and has, we believe, been experimented upon on a small scale with some success, but has not been practically applied. He proposes to arrange the plating very similarly to that shown in section *a*, Fig. 34, page 305; but instead of bringing the edges of adjacent strakes close together, to leave narrow spaces between them, and to treat the butts similarly. Into these spaces strips of wood would be driven, and to these strips the edges of the zinc sheets would be nailed. The sheets would consequently require to be of the same size as the plates, and their centres would be secured by a few small studs. Felt or some other material of a similar kind is proposed for use as a bedding to the sheets, in order to reduce the amount of contact between the zinc and the iron. Various objections have been raised to the structural arrangements which this plan would render necessary —the edge-strips, numerous liners, and broader butt-straps that would be needed; the want of proper fitting of iron to iron at the butt-joints; the greater labour of plating and caulking, etc. These objections, doubtless, have some force, and probably have contributed to prevent any ship being thus built and sheathed.

In another plan, proposed by Mr. Bell, the plating would be worked as usual, except that strips of plating would be fitted between the laps of the raised and sunken strakes in order to increase the depth of the recesses over the latter. Thin wood planking, arranged diagonally, would be fitted into the recesses, and secured to the sunken strakes by a few bolts. To these planks the zinc sheathing would be nailed, and would consequently, unless some material were interposed, be in direct contact with all the outer strakes of plating; but it is proposed to regulate the amount of contact by trial. An alternative proposition by the same gentleman is to plate the ship as shown in Fig. 49, and to fit the wood planks between thick edge-strips similar to *s*, *s*. The zinc sheets would then touch the edge-strips only, and their surface of contact would be much less than on the other plan. Iron nails in the zinc sheathing are suggested as a simple means of increasing the metallic connection if that should prove desirable. So far as we know, neither of these plans have been practically tested, and it is unnecessary to criticise them.

The last plan we shall describe is now under trial in one of the iron-clad ships of the navy. It was proposed by the late Mr. Lungley, and is illustrated by Fig. 51. The outside plating is worked on the usual in-and-out plan; and to secure the wood planking to which the zinc sheets are nailed, channel-irons (*a*, *a*) are riveted to the iron skin. The planking is fitted diagonally between these channel-irons, and the zinc sheets consequently come into direct contact with iron only at the edges of the channels. Metallic connection is, however, made by the nails in the sheathing, these passing through the wood and touching the iron plates; and the amount of the action set up on the zinc may obviously be increased by using iron or metal nails instead of zinc. The experiment has not yet extended over a period sufficiently long to lead to conclusive results; but it will probably do much to advance our knowledge of the conditions essential to the successful use of zinc sheathing. Experience of a more decided character is required before ship-builders will be able to employ zinc with the certainty of success; but should this be obtained, the cheaper metal will, no doubt, be extensively used instead of copper.

SEATS OF INDUSTRY.—XXIX.

BRISTOL.

BY WILLIAM WATT WEBSTER.

One of the most ancient cities and centres of trade and manufactures in the United Kingdom, and for a long period second only to the metropolis in commercial and social importance, Bristol, though outstripped by younger rivals, still takes high rank among the towns of Great Britain, and the story of its rise, pre-eminence, and relative decline, forms a singularly interesting and instructive chapter in the history of English commerce. We say *relative* decline, because Bristol has in reality suffered no positive decadence, although it has not recently progressed at the same rate as some other more fortunately-situated towns in this country. There does not appear to have been any very marked falling off either in the enterprise or in the intelligence of the inhabitants of this famous city in more modern times; it is rather the great opportunity that has been lacking to them. The current of commercial prosperity would seem to have changed its course, and left Bristol in an eddy of the stream. An examination of the chief causes that have contributed to raise Liverpool, for instance, into the position it now occupies, and to throw Bristol into comparative obscurity, will show that the latter could not possibly have taken advantage of them. Indeed, the later trading history of Bristol, considered in connection with that of English towns which have increased more rapidly in population and wealth, forcibly illustrates the effect that the introduction of new industries exercises in determining the relative importance of commercial and manufacturing centres. It is to its proximity to the great manufacturing districts of the north of England, as we have seen in a previous paper, that Liverpool is principally indebted for its extraordinary development and growth. Bristol had not in its neighbourhood the resources necessary for the carrying on of such extensive manufacturing enterprises as constitute the foundation of the prosperity of Liverpool.

Nothing is known of the origin of Bristol, but under the names *Caer Brito* and *Caer Oder*—the latter signifying the "town of the chasm," and denoting its position by the "rifted rock" —it is supposed that it can be traced to a period as far back as the time of the ancient Britons. The Romans fortified the place, and after their departure from the island, it fell back into possession of the native princes, and formed part of the territory of the Cornish Britons. It is included in the lists of fortified and eminent towns drawn up by Gildas in the fifth, and by Nennius in the seventh century; and in 584 it was captured by Crida, King of the West Saxons. Its present name is generally believed to be a corruption of the Saxon compound *Brice-stow* or *Bright-stowe*, which means "a pleasant place;" but numerous other explanations of it are given. It would appear to have been visited by Jordan, one of the monks who came to Britain with Augustin; and certain antiquarians contend that Bristol was the scene of the famous conference between the Roman missionary and the British bishops in 603. The first unequivocal mention of the place in history, however, is in the reign of Athelstan, in the beginning of the tenth century. Next to London Bristol was the principal port in the country in Anglo-Saxon times. In a memoir of Wulfstan, the Bishop of Worcester at the time of the Norman Conquest, the following passage occurs:—"There is a seaport town called Bristol, opposite to Ireland, to which its inhabitants make frequent voyages of trade. Wulfstan cured the people of this town of a most odious custom which they derived from their ancestors, of buying men and women in all parts of England, and exporting them to Ireland for the sake of gain. You might have seen, with sorrow, long ranks of youths and maidens of the greatest beauty tied together with ropes and daily exposed for sale; nor were these men ashamed—oh, horrid wickedness!—to give up their nearest relations, even their own children to slavery." In the "Domesday Survey" the town is called *Bristow*, and it was then a royal borough, its governor being a noted merchant, said to be of Danish origin, named Hardinge, whose son, Robert Fitz-

hardinge, the first Lord of Berkeley, succeeded to the government. In the reign of William Rufus the fortifications of the town were strengthened. Bristol was captured in the reign of Stephen by Robert Earl of Gloucester, the illegitimate son of Henry I., and held by him for his sister Maud, during which time the castle was rebuilt and enlarged, and made one of the strongest in the country, its walls being about twenty-five feet thick. In this castle Henry II. was partially educated, and Stephen was for a short time a prisoner. About the year 1140, a monastery of the Augustine order was established at Bristol by Robert Fitzhardinge; it was made an abbey by Henry II., and continued to flourish till the dissolution of the monasteries by Henry VIII. in 1540, at which time its revenues amounted to £767. Fitzhardinge also founded the priory of St. James, the church of which was afterwards made parochial, and a nunnery was built by Eva his widow. William of Malmesbury, who died in 1148, speaks of Bristol as "a very celebrated town in which there was a port, the resort of ships coming from Ireland, Norway, and other countries beyond sea." Henry II. granted the town a charter in 1165, increasing its commercial privileges, and in 1175 he took possession of the castle. Early in the thirteenth century a new channel was cut for the river, and a new quay, adapted to the extensive and growing trade of the port, was constructed. For its time this was a remarkable engineering work. In 1285 Edward I. assembled a Parliament at Bristol. A few years later a Bristol merchant, named Walter Hobbe, seized a ship and cargo in the port, belonging to a merchant from Holland, but after a long course of litigation he was forced to surrender both, and pay £65 for the loss he had caused the Dutchman to sustain. The old chronicler who relates this incident remarks that it would be "a thing of great danger at those times, and such as might occasion a war, to suffer alien merchants, particularly those of Holland and Brabant, to depart without having justice done them," which is surely a sensible comment so far as it goes. Bristol was the seat of a rebellion in the reign of Edward II., and held out for four years against the royal forces. About this date extensive manufactures of soap, cloth, and glass were carried on in the city; and in the reign of Edward III. many of the weavers who had come over to England from Flanders settled in Bristol, and materially contributed to its prosperity by making it the chief centre of the woollen manufactures of the kingdom. Blankets were first made by, and derive their name from a Flemish manufacturer named Thomas Blanket, who, with his two brothers, were among the earliest promoters of cloth-making in Bristol. As a matter of course, Mr. Blanket's innovations were opposed by the civic authorities, who in 1340 fined him heavily "for having caused various machines for weaving and making woollen cloths to be set up in his house, and for having hired weavers and other workmen for this purpose;" but the fine was afterwards remitted by a special injunction from Edward III. After a short time the inhabitants of Bristol perceived that the inventor of the blanket was a public benefactor, and he was made bailiff of the city. He and his two elder brothers carried on an extensive home and foreign trade for many years, and from their time till the discovery of America cloth was the principal article of commerce in Bristol. It was made one of the staple towns for wool by Edward III. in 1353, and twenty years later this monarch constituted the city a county in itself and declared it free from all feudal obligations. As an evidence of the wealth of Bristol at this period, it may be mentioned that it furnished 22 ships and 608 seamen, a force as large as that contributed by London, to the fleet sent to besiege Calais shortly after the battle of Crecy in 1346. Bristol was besieged and taken in 1399 by Henry Duke of Lancaster, who in the same year ascended the throne as Henry IV. In a charter granted by this monarch in the following year, acknowledgment is made of "the many and notable services which very many merchants, burgesses of our town of Bristol, have done for us and our famous progenitors in many ways with their ships and voyages, at their own charges and expense."

During the second half of the fourteenth century there flourished at Bristol a famous merchant and manufacturer, William Canynge or Canning, the founder of a family to which the city was greatly indebted. He was twice bailiff, six times mayor, and three times returned as representative of Bristol in Parliament. In 1396 he died, leaving a large fortune acquired principally by foreign trade, the greater part of which was devoted to charitable objects. His son John was also a merchant of repute, and served the town in the capacities of bailiff, sheriff, member of Parliament and mayor, and at his death, in 1405, he left a third of his goods to his wife, a third to his children, and a third to the poor. Thomas Canynge, the eldest of John's descendants, settled in London, and rose to the dignity of member of Parliament for the City in 1451, and mayor in 1456. When he was sheriff of the metropolis in 1450, he took part in the suppression of Jack Cade's rebellion, as we learn from a petition addressed to Henry VI. by himself and his fellow-sheriff, asking remuneration for the expense, trouble, and danger they had incurred in "drawing the body of the great traitor upon a hurdle by the streets of the City of London," and in distributing the head and quarters as directed; "the which commandments," says the petition, "were duly executed to their great charges and costs, and especially for the carriage of the quarters aforesaid, for and because that hardly any persons durst or would take upon them the carriage of the said head and quarters for doubt of their lives." Thomas Canynge was considered a man of great energy and high character, but his brother William, known as William Canynge the younger, who was born in 1399 or 1400, greatly excelled him and all his family, indeed, in wealth and fame. This was the greatest of Bristol's old merchant princes. By the middle of the fifteenth century there were about 66 ships and about as many boats belonging to the port, and its merchants carried on an extensive trade not only with Ireland and Wales, but also with France, Russia, Prussia, and the Levant. William Canynge the younger, during the eight years preceding 1460, employed on an average 800 seamen in the navigation of his ten vessels, which had an aggregate burden of 2,930 tons. He gave occupation besides to about 100 artisans. Several of Canynge's ships were among the largest of their day; the *Mary and John* being 900 tons, the *Mary Redcliffe* 500 tons, and the *Mary Canynge* 400 tons burden, and the three cost him in all 4,000 marks, or considerably more than £25,000 in our money. By a treaty concluded between Henry VI. and the King of Denmark, the merchants of Bristol and several other towns were forbidden to trade with the inhabitants of Iceland, Finland, and other districts subject to the Danish crown; but the Danish king made an exception of William Canynge, who was permitted, "in consideration of the great debt due to the said merchant from his subjects of Iceland and Finmark, to lade certain English ships with merchandise for those prohibited ports, and there to take fish and other goods in return." In 1449 Henry VI. sent letters of commendation to the Master-General of Prussia and the magistrates of Dantzic, inviting their favour towards certain English factors established within their jurisdictions, and especially towards William Canynge, "his beloved and eminent merchant of Bristol." Canynge, like his grandfather, passed through all the higher offices of his native city, and greatly distinguished himself. He was a staunch supporter of the Lancastrian cause, and at his own expense built "a stately vessel only for war," to protect the city against the Yorkists. In 1456 he entertained Margaret of Anjou when she visited Bristol for the purpose of quickening the interest of the western counties in the falling fortunes of her husband. Five years later, on the failure of the Lancastrian cause, Canynge had to welcome Edward IV. to the city, when that monarch came to ascertain how much money could be levied from the wealthy merchants of Bristol. Being the richest man in the town, and at the same time the most zealous supporter of the Lancastrian house, Canynge had to pay the king 3,000 marks, or about £20,000, "for the making of his peace," but he was also instrumental in securing certain important trading privileges for Bristol, in return for the money he and his townsmen delivered to his majesty. During his last mayoralty, Canynge formed the merchants of Bristol into a guild, for mutual protection in regulating the prices of various articles of trade and for mutual help in misfortune, which although repugnant to modern economical policy, exercised at that time and for a long period after a beneficial influence on the commerce of the city. He spent much of his wealth on the restoration of the ancient and noble church of St. Mary Redcliffe, and in 1467, his wife and children being all dead, "he gave up the world, and in all haste took orders upon him, and in the year following was made priest and sang his first mass at Our Lady of Redcliffe." It is said that Canynge was induced to take this step in consequence of a project of Edward IV. for finding him another wife, and exact-

ing a large sum of money for his matrimonial agency fee. In Canynge's time there was a large number of great merchants in Bristol, including Robert Sturmy, who lived in lordly style and had extensive dealings with the Levant, and the brothers Jay, a family that was famous in two generations. In a work written towards the close of the fifteenth century, we read that in 1480 "a ship of John Jay the younger, of 800 tons, and another, began their voyage from King's Road to the island of Brazil, to the west of Ireland, ploughing their way through the sea." The ships did not discover the "island," although they sailed the sea for nine months; but was this a veritable voyage of discovery, or is there some mistake in the record?

There seems to be no good reason for doubting that John Jay at this early date sent out ships in quest of a new field for trade on the other side of the Atlantic. The Spanish ambassador at the English Court informed his sovereign in a dispatch dated 1498, that "for the last seven years the people of Bristol have sent out every year two, three, or four light ships in search of the island of Brazil and the seven cities;" and if we accept this statement as correct, it proves that the merchants of this town were searching for the New World at least two years before Columbus made his first voyage of discovery. But whether this be so or not, there is no room for doubting that a Bristol merchant of Venetian birth, named John Cabot, landed on the American continent before either Columbus or Americo Vespuccio. On the 5th of March John Cabot obtained from Henry VII., for himself and his three sons, Sebastian, Ludovico, and Sanzio, letters patent for the discovery of new lands, and in May of the following year he sailed out of Bristol with two vessels manned by a crew of three hundred men, which he had equipped with the help of his brother merchants. On the 24th of June he sighted land, which he supposed to be Cathay, "the territory of the Great Khan," but which turned out to be Labrador. In 1498 Sebastian Cabot left Bristol with a small fleet, and after searching for a north-western passage to India, explored the North American coast as far as Chesapeake Bay. The Cabots made no profit out of these expeditions, but at a later period their townsmen established a trade with Newfoundland that largely contributed to the prosperity of Bristol. On the visit that he paid to Bristol in 1487, Henry VII. marked his sense of the wealth and luxury that prevailed in the city by imposing a fine on such of the citizens as possessed property to the value of £20, on the pretext that the ladies dressed in too gorgeous and costly robes. The kings of England in those times resorted to peculiar methods of raising money.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

IX.—NATIONAL MUSEUMS (*continued*).

FROM what has been stated in previous articles it will be seen that the severance of the natural history from the antiquarian and bibliothecal collections of the British Museum will afford ample space for the time being, in the Bloomsbury building, for the development of the collections illustrative of *human history*, which should include specimens from the Tower armouries (the Meyrick collection being lost to the nation), Woolwich Arsenal, and Indian Museums. An extension of the National Gallery building would allow of the sculpture and pictorial art treasures being arranged in such manner as would best illustrate *Art*, and extend a sound knowledge of its principles among the people. *Practical Art* and *Economic Science* should find a place in their recognised home at the South Kensington Museum, in association with a teaching staff at the Science and Art Schools, while *Natural History* in its purely scientific aspects would find ample space for its full development according to modern ideas on the site now secured for the New Museum, to the south of the International Exhibition. Were the Economic Collections of the Kew Museum brought into association with the Museum of Practical Geology and the Food Collections of South Kensington, the Botanic Gardens at Kew would afford the collection of living plants desired by the memorialists of 1858; and it might be a question whether Government should not assist the Zoological Society with an annual grant, on the condition that the living animals should be grouped in more systematic order, and that that powerful aid to a knowledge of the habits of the invertebrata, the aquarium, should be re-organised, according to the latest experience, as developed at the Crystal Palace by that enthusiastic practical naturalist, Mr. Alford Lloyd, for in its present condition the aquarium house is a disgrace to the gardens of the Zoological Society.

I shall devote the remainder of this article on our science, art, and antiquarian collections, to a description of what the arrangement and management of a "National Museum of Natural History" ought to be, taken as a typical model open to modification according to the requirements of any given locality. It should comprise two separate buildings. One should be devoted to an elementary series forming an epitome of the leading principles of natural history, so constructed that it would provide for the general public being admitted not only during the hours of the day, but in the evening, for the benefit of the working classes and others engaged in business during the day. The other building would be devoted to the scientific or classified collections, and should be constructed so as to provide for the convenience of the general public, and the special requirements of students and scientific naturalists between the hours of ten and four. The two buildings should be sufficiently isolated, to provide against the destruction of the Scientific Museum, should a fire by any accident arise in the Elementary Museum. It would therefore be better to place the Elementary Museum at one end, rather than in the middle of the buildings, as proposed in Professor Owen's plans of 1859 and 1862; for though such a disposition may appear more symmetrical from an architectural aspect, in the event of a fire occurring in a central structure—the Elementary Museum being the only part where artificial illumination should be admissible—the destructive element would literally be provided with two strings to its bow, and the difficulty of confining a conflagration to its narrowest limits would be materially increased. The smaller building might be called the "Index Museum," or as Professor Owen considers a circular structure would be the most convenient form, as it "admits of the most economic and effective supervision" for an introductory series, the "Rotunda of Elementary Natural History" would provide a designation that would perfectly define its aims.

Estimate of Space.—On the first announcement of Professor Owen's scheme for a new Museum for the British Natural History Collections, much misconception prevailed, and even prevails to the present day, as to his real ideas on the subject, which may have arisen from misstatements of his views, similar to that made by Mr. Gregory when he announced in Parliament that a gallery of 850 feet in length was proposed to be devoted to whales. The truth was, that 850 feet was specified in the plan of 1859 as the entire length of the "Mammalian Gallery," but the veriest schoolboy ought to know that the single *order* Cetacea does not constitute the entire *class* Mammalia. Yet this gross misrepresentation led to Lord Palmerston's protest against the admission of whales into our National Museum, and making the quaint suggestion for the excision of the cetaceans out of the scheme of Nature. Now that science is being taught in our great public schools, such as Eton, Rugby, Marlborough, Winchester, and the masters are desirous of teaching it still more extensively on the soundest basis that our scientific educationists can indicate and practical experience establish, we may hope in future days to be saved from such lamentable displays of ignorance on the most elementary conceptions of the aims of the naturalist, under the roof that covers "the collective wisdom" of our country, by those who would patronisingly pat an Owen or a Huxley on the back as "men fond of beetles." Professor Owen's scheme has been regarded as "extravagant" both as to idea and cost, if carried into execution; but when the keepers of the several departments came to make estimates of space for their individual requirements, it was found that their demands exceeded those originally made by Professor Owen in 1859.

It will be found that Professor Owen always has spoken in his printed reports and works as to the necessity of the curator being guided by "the principle of selection" as to what specimens were best suited for public display, though he enforces the necessity for the skins and skeletons of all large animals being arranged in the public galleries, as unwieldy specimens could thus be more conveniently examined than if kept packed in boxes, etc., in the store-rooms or studies; for though boxes,

drawers, etc., may be a convenient and practical arrangement for specimens of birds, bats, and "such small deer," the system does not hold good for bulky or pachydermatous animals, as common sense indicates. On referring to the tabular form given at page 320, under the column headed "Estimate of New Museum," it will be seen, that according to the returns of the keepers of the several departments, based on the data laid down by Professor Owen, previously defined, a gallery length of at least 7,400 feet by an average width of 50 feet, together with an area of about 300 square feet for an Index Museum, is essential for the proper display of any National Collection of Natural History; or an entire area of 322,100 square feet, equal to about seven and a quarter acres, and add, as Professor Owen says in his Report of 1862, "for architectural requirements, for light, access, galleries, halls, symmetry, and ornament,* say three acres, and the whole would call for a building of two storeys upon about five and a-half acres of ground."† This, says Professor Owen, in his edition of 1862,‡ "is scarcely one-sixth the size of the Exhibition Building of 1862, for the arrangement and display of the samples of industrial products of the present generation." "One mile of galleries stored with examples of creative skill may leave the traverser somewhat wearied, but thousands gladly court the greater fatigue of six miles of gallery stored with the works of industry of all nations."

Professor Huxley, in his examination before the British Museum Parliamentary Committee,§ stated that he considered six such rooms as the Ornithological Gallery in the British Museum (which is 300 feet long by 45 feet wide), "with appropriate offices," would afford ample space not only for the existing zoological collections, but also for future additions for fifty years to come. This would only amount to a gallery length of 1,800 feet, or 2,600 feet less in length than estimated by the officers of the British Museum. By reduplication at the ends of the rooms, the absolute length of wall-cases (having a depth of 3 feet) in the Ornithological Gallery equals 900 feet, and the floor-space allows of two rows of table-cases 10 feet long by 4 feet 7 inches wide, with an allowance of 3 feet space between the cases. Such a Zoological Museum (*without the appropriate offices!*) would not cover more than 2 acres of ground. As an illustration of the ratio of specimens required for public exhibition on the typical system, Professor Huxley considered that 1,500 species would be a very large allowance for the needful illustration of ornithology as to form, colour, and structure, and that the male, female, and young, different ages or varieties of the same animal need only be exhibited, where any law, fact, or considerable truth could be illustrated. "Every *fact* of variation should be properly illustrated, but every variety, say of the class of birds, should not be exhibited in the public galleries." The estimate of that practical curator, Professor Agassiz, for the Museum of Comparative Zoology of the State of Massachusetts, not only confirms, but exceeds that made by Professor Owen, as for the illustration of zoology solely, he required and secured "an oblong square of about five acres," on which galleries having a collective length of 6,000 feet by 50 feet wide have been built. We may therefore assume that the estimate for space for the New Museum of General Natural History is not founded on extravagant ideas or an unsound basis, when two such eminent naturalists as Professors Owen and Agassiz, who have devoted the greater part of their lives to the details of Museum arrangements, independently arrive at such a close approximation to the same conclusion; and I believe another practical curator, Professor Flower, the Conservator of the Museum of the Royal College of Surgeons, also considers the space specified in Professor Owen's Report essential for the proper elaboration of the National Museum of a great, wealthy, and intellectual country. Now that the desired ten acres of ground has been acquired, Mr. Waterhouse's plans approved, and £35,000 voted for the erection of the Museum, it is to be hoped the building will be speedily completed. It is to be regretted that the debate of 1860 had the effect of postponing the decision of Government on such an important question for a period of twelve years.

* In an article contributed to the *Gardener's Chronicle* (page 749, vol. for 1858) Dr. Hooker suggests the advantage of a grass-plot being laid round a Museum, as "it not only cools and moistens the impending atmosphere, but mechanically retains the dust swept off surrounding objects by surface currents."

† Parliamentary Papers, Vol. XXXII., 1864.

‡ "On the Extent and Aims," etc., previously cited.

§ See Parliamentary Papers, Vol. XVI., 1860.

MINING AND QUARRYING.—XXV.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

ASSAYING—SMELTING—THEORY—SMELTING IN REVERBERATORY FURNACES AT ONE OPERATION—CALCINERS—FLOWING FURNACES—THE ORE HEARTH—SLAG HEARTH.

In North Wales a flat iron bason with a lip is used, and if the ores are rich they are reduced in this without the addition of any flux whatever, but if poor a little carbonate of soda is added. The bason is covered with a close-fitting iron lid, and then put into an open forge for five minutes. By that time the greater portion of the metal is separated, and a scum, or slurry (as it is there called), is found to cover the surface. This is pushed to the back of the bason, and as soon as the slurry has sufficiently solidified the lead is poured out into a mould. The slag is then re-heated for about an equal time, to free any metal that may have become mechanically suspended by it, and this is then poured out as before. The sum of these two meltings will give with great exactness the quantity of metal in the ore.

If earthen crucibles are used, some small pieces of iron, or wrought-iron nails, are put into the crucible, care being taken that they reach to the bottom, or else some of the sulphide may escape decomposition. All the pieces of iron must be withdrawn before the contents of the crucible are allowed to cool, or they will become fixed in the lead.

Any silver that may be present in the ore, will be found in the button of lead weighed by the assayer, so that the result must not be understood to represent the per-centage of pure metal, but of the argentiferous lead. In a small sample, such as 10 oz., which is a common quantity to be assayed at a time, the silver will only be represented by a fractional quantity, as 0·1 per cent. of silver is equal to a yield of $32\frac{2}{3}$ ounces to the ton. The same remark will apply to the gold; but it scarcely ever happens that it amounts to an appreciable quantity, even in an assay balance of the most delicate construction. Sulphide of antimony, which is not an uncommon ingredient of lead ores, will in like manner affect the result of the assay. If copper is present, about one-third will probably find its way into the metal, the remainder being retained in the slag. Iron will not affect the assay at all, as the whole of it will pass into the slag. Zinc and arsenic, being both very volatile substances, will not interfere with the calculations of the assayer.

At many of the great lead mines, such as those of Mr. W. B. Beaumont, at Allenheads, the reduction-works are on the spot, and form part of the same establishment, so that the ores obtained from them do not come upon the market; but where the ores have to be sold to smelters, this is generally done by ticket, upon the same plan that tin and copper ores are sold in Cornwall and Swansea. The argentiferous ores, which term includes all those which contain sufficient silver to cover the cost of separation, are of course assayed for both metals, and fetch a corresponding price. Anything above from two to three ounces of silver to the ton will repay the cost of desilverisation.

The smelting of lead is a comparatively simple process theoretically, but it will be seen from the following descriptions that in practical operation there are a great many details which call for the exercise of ingenuity, and which also involve a very heavy outlay for plant.

The theory of the process consists in converting the ore, which is the sulphide of lead (PbS), into either the oxide (PbO) or the sulphate ($PbSO_4$); and then fusing either or both these with a quantity of the unchanged ore in certain proportions which will yield metallic lead (Pb) and sulphurous acid (SO_2).

The following formulæ will show what relative proportions will give the best result; that is, will liberate the whole of the lead in the ingredients. No other proportions will be found to fulfil this condition:—

2 of oxide to 1 of sulphide ($2PbO + PbS = 3Pb + SO_2$).

1 of sulphate to 1 of sulphide ($PbSO_4 + PbS = 2Pb + 2SO_2$).

1 of sulphate and 2 of oxide to 2 of sulphide ($PbSO_4 + 2PbO + 2PbS = 5Pb + 3SO_2$).

In practice, of course, exact results like these cannot be at-

tained: firstly, because none of the ingredients are perfectly pure; secondly, because there is always more or less reaction between them and the materials of which the furnace is composed; and thirdly, because lead is easily volatilised, and a considerable portion of the metal passes away in the fumes. Owing to these unavoidable sources of error, it is found that there is nearly always an excess of the oxide and sulphate, and, therefore, that the proportion of lead represented by the undecomposed portion of them is left unreduced.

Almost all the lead works in this country are conducted upon the principle of this double reaction; but there are different modes of carrying it out, which will have to be noticed separately. At many of the Continental establishments, especially where the ore consists largely of silicates, the lead is reduced by the direct action of metallic iron—an application on a large scale of the principle described above for the assay of lead ores.

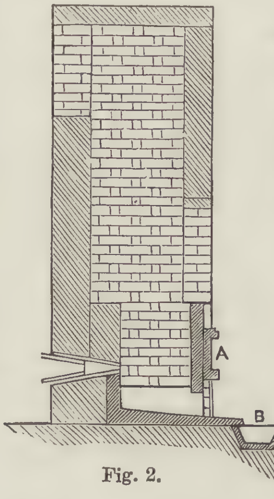


Fig. 2.

To return to the English practice. There are two kinds of furnaces used—the reverberatory and the blast furnace. The use of the latter, called the "ore hearth," is almost confined to the northern counties and to Scotland.

The reader will ere this be so familiar with the ordinary arrangements of the former that a lengthened description will be unnecessary. One reverberatory furnace may be made to yield the metallic lead from the dressed ore at a single operation; but in some works the calcining of the ore and the subsequent reduction of the metal are conducted separately in their respective furnaces.

The entire operation, according to the first plan, is accomplished in 4½ to 5 hours. The hearth of the furnace is made to slope down from each end and the back, to the centre of the front side, which part is connected by a pipe with a bason for the molten metal outside the furnace, similar to that used in the smelting of tin. The sole or hearth is made of old slag broken up, and heated sufficiently to enable it to be beaten down into a solid mass. The ore is supplied through a hopper in the roof, and there are usually three working doors on each side of the furnace through which the furnace-man and his attendant work the charge.

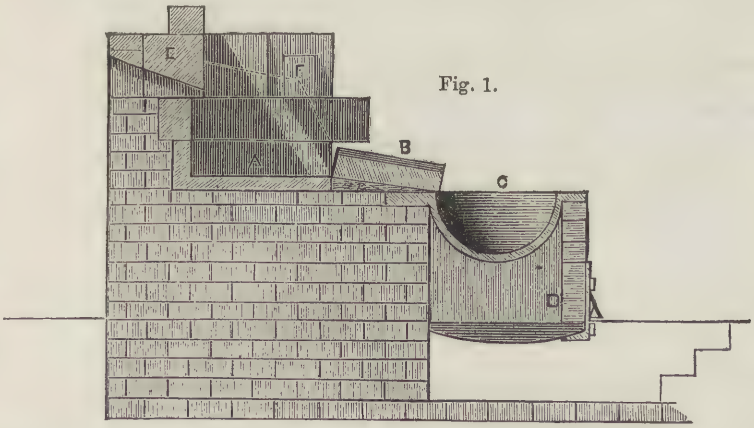


Fig. 1.

The temperature of the furnace is only moderate when the charge, say 20 cwt., of ore is introduced through the hopper. The assistant immediately spreads it evenly with his rake over the hearth. Then the furnace-man skims off the slags resulting from the previous charge, which overlie the lead in the bason outside, and throws them into the furnace by the working door furthest removed from the fire. The metal from these slags soon runs down and flows through the pipe into the bason. A second skimming takes place, and the slag is thrown into the furnace as before. While the assistant at the back is attending to the present charge, the furnace-man ladles the lead from the preceding one out of the bason and pours it into the pig-moulds. At the end of two hours, during which time the temperature of the furnace has always been kept at only a dull red heat, and a plentiful supply of air has been admitted by the working doors, the roasting or calcination of the ore is complete, and the second process, or smelting, begins. In this the fire is increased and the doors closed, so that in half an hour the furnace will be got up to a bright red heat, and the lead will be found flowing down towards the middle. The slags are then raked up to the ends and spread out, and some quicklime is thrown in upon the lead. The charge is then well worked by both the smelter and his assistant for about half an hour. The furnace is next allowed to cool down a little, after which the process just described is repeated twice, the temperature each time being raised rather higher than on the preceding. The tap-hole is then pierced, and the lead is allowed to run out into the bason. The slag which remains behind upon the sole of the furnace is poorer in quality than that which flows with the lead into the bason, and is raked out by the assistant and put on one side for subsequent treatment by a separate process.

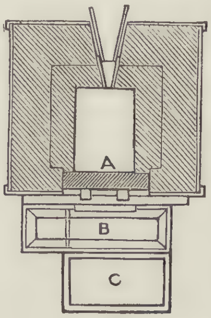


Fig. 3.

The result will probably be about 15 to 16 cwt. of metal, as it is usual at most works to mix the rich and poor ores together, so as to make a fair average quality of material. This plan has not only the advantage of rendering the working of the furnace regular, but the poor ores serve as a flux to the richer, and so render the use of an artificial one unnecessary. From 1 to 2 cwt. of lime is used to make the slags drier or less fusible, and the coal consumed for each charge will be about 10 cwt.

During the calcination the free admission of air causes the partial oxidation of the sulphide, so that the contents of the furnace at the close of that stage of the process will more or less closely agree with one or other of the formulæ given above, and contain all the elements for the double decomposition represented in those equations.

In Cornwall and some other parts, the calciner and the flowing furnace are separate. They are both made on the reverberatory principle. The sole of the former is flat, and there is no special feature connected with it to call for particular remark. That of the flowing furnace is hollowed towards the part opposite the channel through which the lead flows into the bason. The rich and poor ores are mixed together prior to calcination, so as to yield a mixture containing from 65 to 70 per cent. of metal. The roasting then proceeds gradually for about eighteen hours; the charge is raked over every hour, and a little lime is added from time to time to prevent the ore from clotting. The calcined ore is spread evenly over the hearth of the flowing furnace, and then the doors are closed and the heat got up for two or three hours, by which time the furnace will be ready to be tapped. This having been done, some lime is then thrown over the slag, and a little scrap iron introduced; the furnace-doors are again closed, and the temperature raised still higher. At the second running the lead will be succeeded by a regulus, which is usually tolerably rich in copper, and is sold to the smelters of that metal; the slag is then allowed to run into a pit at the side, and is so free from metal as not to be worth further manipulation.

The "ore hearth" is of quite another construction, and the principal fuel consumed in it is peat. Hence its suitability for the northern parts of the kingdom, where peat is the cheapest fuel. The construction of this (which is sometimes also called the Scotch furnace) may be understood from the accompanying diagram (Fig. 1), which represents a section from back to front merely of the working part. Above the upper line is carried a hood for collecting the heated fumes, and the flues by which they are carried off to the condensing chambers. The hearth-bottom itself is represented by A, the work-stone by B, in the centre of which is a groove for carrying any lead which flows over into the bason C. This last is kept warm by a small fire at D; E is called the pipe-stone, as it contains the funnel-shaped aperture which holds the twyer; and F the forestone, which extends across the front of the furnace, and which can be raised somewhat if a full charge should be worked, in which case the contents will reach as high as the dotted line.

In most cases it is found desirable to calcine the ores before reducing them by this process, though some qualities may work very well without this preliminary operation. A smelting shift, as it is termed, lasts from twelve to fifteen hours, and is worked by two men. When the ore-hearth is ready for work, the hearth-bottom A is already full of melted lead and brouse, the latter being the local name applied to a mixture of half-reduced ore and slag. A little coal is first sprinkled over the surface, and then the peat is built up in the form indicated by the dotted line; some peats already ignited are placed in front of the nozzle of the twyer, and the blast is immediately turned on. When the whole of the fuel is properly ignited, some brouse is thrown in on the top behind the fore-stone F. As soon as the lead begins to flow, the workman thrusts his poker into the hearth-bottom and stirs it up, which causes some of the contents to fall upon the workstone; any grey slag that may be mixed with it is separated and put on one side for future treatment, and the brouse (which has become further oxidised during its short exposure to the air while on the work-stone) is shovelled up and returned to the hearth along with some fresh ore. At each stirring of the contents, which is now repeated every five minutes, the assistant places a fresh peat in front of the twyer, and re-arranges the rest, so that the blast may be evenly distributed throughout. When the receiving-pot is sufficiently full of lead, the one man keeps the surface skimmed while the other ladles the lead out into the pig-moulds. The metal produced by this process is usually very pure, as the temperature employed is too low to reduce any of the other metals there may be in the ore, except the silver, which always comes over with the lead.

Whether the reverberatory or the blast furnace be used, it will be seen from the foregoing descriptions that there are certain slags, the grey or furnace slags, which are put on one side to be treated separately. These consist principally of the oxide of lead with occasionally a little both of the sulphate and sulphide, and a large proportion of earthy ingredients, such as silica, baryta, lime, etc. When a sufficient quantity of these slags have been accumulated they are reduced in another kind of blast-furnace called the slag-hearth.

Figs. 2 and 3 will give the elevation in section, and a horizontal plan of this furnace on the level of the twyer. The construction of it will be very readily understood from the drawings. The slags which have to be reduced in this hearth seldom contain so much as 35 per cent. of lead, and are altogether more refractory in their composition, so that a much greater heat is required; and a mixture of coke and peat is selected as the fuel in the north of England.

About one and a-half to two hours are employed in getting the furnace up to a sufficient temperature, when the grey slag mixed with a little brouse is thrown in. After a sufficient time has elapsed to admit of the lead having begun to separate, the furnace-man makes a hole with a pointed iron rod in the clay stopping immediately below the fore-stone A, and the slag then runs out over the lead through B into the slag-pit C. The lead trough, it will be seen, is divided into two compartments, which communicate with one another by a little hole at the bottom of the iron plate which separates them. The larger compartment is filled up with spongy cinders, which act as a filter, the lead percolating through them and passing on to the smaller compartment, while the slag flows on to C. At the close of the operation, the clay stopping is all removed, and the imperfectly reduced slag remaining on the floor of the hearth (which is called slag-hearth brouse) is raked out and put on one side for use in the next shift. Slag lead is rarely so pure in quality as the metal yielded by the regular processes, as it is necessary to employ a temperature which will reduce the iron and other metals that may be in the slags.

In the foregoing descriptions we have purposely omitted all reference to the arrangements for the collection of the fumes arising from the expulsion of the sulphur, and more particularly from the partial volatilisation of the lead itself. It will be remembered from the description given of copper smelting (Article XX.), that the sulphurous acid evolved is destructive to all vegetation; but beyond this the lead salts are all highly poisonous, and if they were allowed to escape into the air from a short chimney, the water and all the herbage and plants around would become so affected by them as to be unfit either for human or animal food. A large quantity of lead would in such case also be irrecoverably lost. The arrangements for the collection of this lead must be reserved for another article.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVI.

BY E. WYNDHAM TARN, M.A.

We now resume the dimensions of work done by the plumber, zinc-worker, gas-fitter, glazier, painter and decorator, and paper-hanger commenced in our last paper.

GLAZIER.

4)	4 8 3 4	62 3	Glazing with 2nds crown, in squares 14″ × 10″.
2)	6 0 3 0	36 0	Ditto best, ditto, ditto, 18″ × 12″.
	6 6 3 0	19 6	Ditto best British sheet, ditto 39″ × 18″.
	6 6 3 0	19 6	Polishing ditto.
	7 0 10 6	73 6	Glazing with best Brit. plate, in sqrs. 7 ft. × 3 ft. 6, ½ in. thick.
	4 0 2 6	10 0	Ditto, ditto, in sqrs. 48″×15″.
	7 0 3 6	24 6	Extra bendg. plate glass.
	4 6 3 0	13 6	Glazg. with rough plate, in sqrs. 27″ × 18″.
6)	8 0 2 0	96 0	Glazing in lead quarries, with tinted cathedral, copper ties, and cementg. into stonewrk.
	3 0 2 0	6 0	Hacking out old glass.

No. 8 doz. sqrs. cleaned.
„ 4 glass tiles, 20″ × 10″.

PAINTER AND DECORATOR.

12)	6 8 3 6	280 0	Knottg. primg., and 4 oils.
4)	6 8 3 6	93 4	Grd. wainscot and 2ce. varnd.
	7 0 5 0	35 0	4 oils skylight.

2)	48 0 9 0	864 0	4 oils and flat to plaster, find. ash green.
2)	15 0 2 6	75 0	3 oils to balusters.
5)	48 0	240 0	4 oils skirting.
2)	48 0	96 0	Skirtg. grd. w., and 2ce. varnd.
	34 0	34 0	3 oils cuttg. to stairs for carpets.
	40 0	40 0	4 oils staff bead.
	16 0	16 0	2 oils edge of shelf.
2)	15 0	30 0	3 oils strings.

No. 4 sash frames 4 oils b. s., 6 ft. by 4 ft.
„ 2 ditto, ditto, 8 ft. by 5 ft. 6 in.
„ 8 dozen squares, ditto, small.
„ 2 ditto, ditto, large.
„ 2 small casements, ditto.
„ 4 stone chimney-pieces, 5 oils.
„ 3 shutter bars, 3 oils.

2)	6 6 3 0	39 0	Staining, sizg., and 2ce. varng.
	8 6	8 6	4 in. letters in gold and shaded.
	48 0	48 0	Gilding 1 in. mouldg.
	24 0 15 0	360 0	Distemper 2 tints.

PAPER-HANGER.

	48 0 10 0	480 0	Hanging 1d. paper, includg. sizing to walls.
	56 0 11 0	616 0	Ditto, 2d. ditto, ditto, and lining paper.
	65 0 12 0	780 0	Ditto, 6d. ditto, ditto, ditto.
	52 0 10 6	546 0	Pumicing, sizing, and stripping old paper, and hanging with 4d. paper.
	40 0 10 6	420 0	Canvas lining for paper.
	75 0 12 0	900 0	Preparg. walls and hanging marbled paper 3d. per yd. on a lining paper, hung in blocks, sized and varnd.
2)	48 0	96 0	Borders.
2)	65 0	130 0	Gold mouldg., 1 in. wide, fixed with needle-pts.

Having completed the series of imaginary dimensions for the plumber's work, etc. etc., we now proceed to form an abstract of them as before. This abstract might have been disposed across the page, so as to exhibit the whole of the work required in the different branches specified, in one table. For convenience' sake, however, it has been found advisable to present the work of the plumber, zinc-fitter, gas-fitter, and glazier in one abstract, and that of the painter and paperhanger in another.

Abstract for Plumber, Zinc-fitter, etc.

Plumber.		Zinc-ftr.	Gas-ftr.	Glazier.
Milld. lead, roof. ft. 720 7 112) 5040 45 cwt. Ditto gutters. ft. 37 6 6 112) 225 2 cwt. 1 lb. Ditto hips. ft. 105 6 112) 630 5 cwt. 70 lb. Ditto step flashg. ft. 42 6 5 112) 212½ 1 cwt. 100½ lb. Ditto cistern. ft. 37 6 / 6 — 225 ft. 12 6 / 7 — 87½ 225 112) 312½ 2 cwt. 88½ lb. Run. Sold. angle, cistern. ft. 17 6 Close nailg. c. nls. ft. 15 0 ¾ in. strong pipe and joints. ft. 12 0 1 in. ditto. ft. 45 0 1¼ in. ditto. ft. 35 0 1½ in. ditto. ft. 16 0 5 in. soil pipe. ft. 32 0	Number. Solder jt., ¾ in. pipe. 2 Ditto 1 in. 2 Ditto 1¼ in. 2 Ditto 1½ in. 2 1¼ in. br. washer and waste. 2 1¼ in. trumpet waste 2 ft. 3 in. long. 1 Service box. 1 ¾ in. ball ck. and c. ball. 1 Ditto bib ditto. 1 1 in. stop ditto. 1 D-trap. 1 Syphon in 1½ in. pipe. 1 W.C. appr. 1 Br. gratg. sold. 1 2½ in. force-pump. 1	Supl. 25 oz. in flat. ft. 126 0 Run. 4 in. eaves gutter. ft. 24 0 2½ in. R. W. P. ft. 30 0 Number. Oct. head to R.W.P. 2 Shoes ditto. 2 Nozzles ditto. 2 Stopd. ends gutter. 4	Run. 1 in. w. i. welded tubing. ft. 55 0 ½ in. tin ditto. ft. 30 0 Number. Short pieces 1 in. tubing. 5 Bends ditto. 3 Tees ditto. 2 Cross ditto. 1 Connectg. piece. 1 1 in. stop-cock. 1 ½ in. union jts. 8 12 in. plain bracket. 4 24 in. dble. ditto. 2 Pendant, hydraulic joint. 1 5 light chandelier. 1	Supl. Glazg. 2nd cr. in sqrs. 14″ × 10″. ft. 62 3 Ditto best ditto, 18″ × 12″. ft. 36 0 Ditto best Brit. sheet, 26 oz., 39″ × 18″. ft. 19 6 Polishg. ditto. ft. 19 6 Glazg. best Brit. plate, ½ in. thick, 7 ft. by 3 ft. 6 in. ft. 73 6 Ditto, ditto, 48″ × 15″. ft. 10 0 Ditto rough plate. ft. 13 6 Bending plate. ft. 24 6 Glazg. in ld. quarries, tintd. cath., copper ties, cementd. to stone. ft. 96 0 Hacking out old glass. ft. 6 0 Number. Squares cleand. 8 doz. Glass tiles, 20″ × 10″. 4

Abstract for Painter and Paperhanger, etc.

Painter and Decorator.				Paperhanger.
2 Oils.	*3 Oils.*	*4 Oils.*	*5 Oils.*	
Run. Shelf edge. ft. 16 0	Supl. Balusters. ft. 9) 75 0 $8\frac{1}{3}$ yds. Run. Cuttg. to treads of stairs. ft. 34 0 Strings. ft. 30 0 Number. Shutter bar. 3	Supl. Knottg. and primg. on deal. ft. 9) 280 0 31 yds. Ditto skylight. ft. 9) 35 0 4 yds. Flattd. to plaster, ash green. ft. 9) 864 0 96 yds. Run. Skirtg. knottd. primed. ft. 240 0 Staff bead. ft. 40 0 Number. Sash frames, b. s. 6 ft. × 4 ft. 4 Ditto. 8 ft. × 5 ft. 6 in. 2 Small squares. 8 doz. Large ditto. 2 doz. Small casements. 2	Number. Stone chimney-piece. 4 Graining and Varng. Supl. ft. 9) 93 4 $10\frac{1}{2}$ yds. Run. Skirting. ft. 96 0 Staining, &c. Supl. Sized and varnd 2ce. ft. 9) 39 0 $4\frac{1}{3}$ yds. Supl. Distemper 2 tints. ft. 9) 360 0 40 yds. Run. 4 in. letters, gold and shaded. 102 inches. 1 in. moldg. gilt. ft. 48 0	Supl. Pparg. walls and hangg. 1d. paper. ft. 5) 480 0 12) 96 0 8 pieces. Ditto, ditto 2d. and lining paper. 5) 616 12) 124 11 pieces. Ditto, ditto 6d. and ditto. ft. 5) 780 0 12) 156 0 13 pieces. Canvas lining. ft. 9) 420 0 47 yds. Marble paper 3d. on lining paper, in blocks, lined, sized and varnd. 5) 900 12) 180 15 pieces. Run. Border. ft. 3) 96 0 12) 32 0 3 doz. yds. 1 in. gold moldg. with needle-points. ft. 130 0

NOTABLE INVENTIONS AND INVENTORS.

XXX.—ISAMBARD KINGDOM BRUNEL.

BY JOHN TIMBS.

This great and original engineer was the only son of Sir Isambard Mark Brunel, and was born at Portsmouth in 1806. As Normandy was the birthplace of both his parents (his mother being a Miss Kingdom, of Rouen), his choice of a school, the college of Henri Quatre, is reasonably explained. He was, as it were, born an engineer, and those who recollect him as a boy will remember how rapidly, almost instinctively, he entered into and identified himself with the plans and pursuits of his father. The son was very early remarkable for his power of mental calculation, and for his rapidity and accuracy as a draughtsman. Nor was this power confined to mechanical drawing, for he thus early evinced a love of art and artistic feeling which characterised him through life. His father watched these early indications, and his education was directed to qualify him for the profession in which he afterwards became distinguished. At the age of fourteen he was placed under the care of Mr. Masson, before he entered the college at Caen, where he remained two years. He there completed a sound, practical education, and learned to observe and investigate facts, to generalise them, and from such inductions to deduce sound rules for practical conduct.

From Caen Brunel returned to England, and commenced his professional career as his father's assistant in the Thames Tunnel works. The energy and ability he displayed in mastering the physical difficulties in this great scientific struggle are duly chronicled in its records; and it has been shown that at this time the anxiety and fatigue he underwent, and an accident he met with, led to future weakness and illness. In one of the irruptions the rush of the water carried him up the shaft. In his descent in a diving-bell to examine the breach made by the irruption the bell was lowered about thirty feet, to the mouth of the opening; but the breach was too narrow to allow it to go lower, that the shield and other works, which lay eight or ten feet deeper, might be examined from the bell. Mr. Brunel, therefore, took hold of the rope, and dived below the bell for the purpose. After he had remained under water about two minutes, his companion in the bell became alarmed, and gave a signal which caused Brunel to rise, when he was surprised to find how much time had elapsed—a circumstance accounted for by the condensation of the air in the bell, from which his lungs were supplied by the pressure of a column of water nearly thirty feet high, which would condense the air into nearly one-half of its usual bulk. Upon a similarly trying occasion Brunel, being an expert swimmer, saved the lives of several workmen at the risk of his own. He was welcomed with a hearty and respectful cheer by the workmen, who crowded round him and wept like children as they affectionately grasped his hand; and the wives of the men he had saved fell on their knees before him, imploring blessings upon him; others cut little pieces from his coat, which they long treasured as relics.

Brunel at an early age possessed the advantage of being able to express or draw clearly and accurately whatever he had matured in his own trained mind. He could also work out with his own hands, if he pleased, the models of his own designs, whether in wood or iron. As a mere workman he would have excelled. Even at this period steam navigation occupied his mind, for he made the model of a boat, and worked it with locomotive contrivances of his own. Everything he did with all his might and strength; and the same energy, thoughtfulness, and accuracy, the same thorough conception and mastery of whatever he undertook, distinguished him in all minor things. ("Stories of Inventors and Discoverers," 1860.)

After the suspension of the Thames Tunnel works, Mr. Brunel became employed on his own account at various works. At Bristol and Sunderland he constructed docks, and he designed a suspension bridge across the Avon at Clifton. When a railway was contemplated between London and Bristol, and a company formed, Brunel was appointed their engineer; and curious it is to read the report of a lecture delivered at Bristol, in the year 1833, by John Britton, the antiquary, upon this means for reviving "the commerce of the west." Brunel's earliest works were on the Bristol and Gloucestershire, the Merthyr and Cardiff, and several colliery tramways, when his mind was first turned to the construction of railways. He was appointed engineer of the Great Western Railway Company, being then only about twenty-eight years of age, but skilful and ingenious, and anxious to strike out an entirely new course of railway engineering. From the great proportion of passenger traffic expected it was proposed to travel at a higher speed upon this line than had been attained upon any other railway. With this view the permanent way was to be peculiarly laid, principally in fixing the gauge at seven feet, a much greater width than had hitherto been adopted, and by which greater steadiness could be ensured than otherwise was consistent with high speed. "The directors seem early to have had misgivings as to the expediency of the change introduced by their engineer; and in 1838, while the line was still under construction, they invited several engineers of eminence to advise with them on the subject. Robert Stephenson and James Walker declined to do so; but Nicholas Wood and John Hawkshaw consented. Both sent in reports which concurred in recommending the adoption of the *narrow* or established gauge, in place of the *broad* or exceptional

one. Mr. Hawkshaw clearly pointed out that the existing gauge had originated in experience, and that the men whose practical knowledge of railways had been greatest saw the least occasion for its alteration; that three-fourths of England was being traversed by the narrow gauge, and it would be a great evil if the Great Western district were to be isolated from all the great lines in its neighbourhood; that nothing was to be gained by increasing the width of the gauge, while much might be lost by the unnecessary expenditure of capital in the first place, and by driving traffic in other directions in the next; and under these circumstances he strongly urged that, as only twenty-two miles of the railway had been laid down at the date of his report, that portion should forthwith be converted into narrow gauge, and the remainder executed of the same width. Mr. Hawkshaw's recommendations were of no avail. Mr. Brunel, Mr. Babbage, and Mr. Russell Gurney opposed their adoption by the company: genius, science, and eloquence carried the day. Mr. Brunel assured the shareholders that the broad gauge was the best gauge, and that the Great Western 'could have no connection with any other of the main lines of railway.' On a division the shareholders endorsed the recommendations of their engineer, and the controversy was for a time put an end to by the completion of the Great Western as a broad-gauge railway, which was so novel that it was called the Grand Experimental Railway; while it rendered Brunel famous as a railway engineer.

"Years passed, and railways of a different gauge met Mr. Brunel's line at many points. Mr. Brunel himself was the engineer of various lines of narrow gauge, thereby admitting its practical sufficiency for railway traffic. The *break of gauge* eventually came to be viewed in the light of a public calamity. The intervention of Parliament was even called for, and a Royal Commission was appointed to take evidence and report on the subject, which they did in 1846. But it was too late to remedy the evil. While an actual saving of capital would have been effected by the adoption of Mr. Hawkshaw's recommendation eight years before, it was now found that the alteration of the Great Western lines from the broad to the narrow gauge would cost upwards of a million sterling. How was this amount to be raised? By the shareholders, or by the public? The question was, indeed, felt to be surrounded with difficulty; and all that the commission did was to recommend the future restriction of the broad gauge lines to their own district. Since that time something has been done to remedy the original evil: the mixed gauge—that is, the narrow gauge with the broad—has been adopted, and gradually extended."

Among the Great Western constructions are the viaduct at Hanwell; the Maidenhead Bridge, which has the flattest arch ever attempted in brickwork; and the Box Tunnel, which at the date of its construction was the longest in the world. The excavation through the solid rock of the latter was satisfactorily accomplished under the direction of Mr. Brunel. This tunnel, which is ventilated by six shafts, varying from 70 to 300 feet in depth, is 3,173 yards in length. It pierces through Box Hill, between Chippenham and Bath, part of which is 400 feet above the level of the railway. The number of bricks used in its construction was 50,000,000; a ton of gunpowder and a ton of candles were consumed every week for two years and a half; and 1,000 men and 250 horses were kept constantly employed.

The tubular bridge over the Tamar, together with the similar bridge over the Wye, the "bowstring girder bridge" at Chepstow, are imposing monuments of Mr. Brunel's boldness and skill. The principle upon which these bridges were planned has been much criticised, but the works executed undoubtedly possess great strength and durability. The foundations of these bridges, under the customary modes adopted with such works, would have been extremely difficult of execution; but Mr. Brunel's ready appreciation of the merits of new discoveries enabled him to take full advantage of the pneumatic process, by a modification of which he established the foundation of the principal pier of the Saltash Bridge, at a depth of water and soft mud at which no works of the kind had been previously founded. It consists of nineteen spans, seventeen wider than the widest arches of old Westminster Bridge; while the other two, resting on a cast-iron pier of four columns, cross the whole stream of the Tamar, at a leap of upwards of 900 feet, or a greater distance than the breadth of the Thames at Westminster. The total length of the structure from end to end is 2,240 feet; its height from foundation to summit is 260 feet, or more than 50 feet higher than the London Monument. The main pier in the centre of the river, on which the great spans rest, has its foundation on solid rock, under some 70 feet of sea-water, with 20 feet of mud and concrete gravel. This was built on the coffer-dam principle. An immense wrought-iron cylinder of boiler plate, 100 feet high and 37 feet in diameter, and weighing upwards of 300 tons, was made and sunk exactly on the spot whence the masonry was to rise; then the water was pumped out and the air forced in; the men descended, and, working as in a gigantic diving-bell at the bottom of the river, cleared out the mud and gravel, until the rock was reached and hewn into form to support the cylinder evenly all round. Powerful steam air-pumps were necessary to keep the labourers supplied below; and they worked at an atmospheric pressure of upwards of 35 lbs. to the inch. On this massive pile, built in the cylinder, the iron columns for the centre pier are raised. Until these ponderous masses were cast, metal works of such dimensions were seldom dreamt of. There are four octagonal columns 10 feet in diameter, 100 feet high, and 150 tons weight. These columns stand 10 feet apart from each other, in the centre of the granite, and are bound together with a massive lattice-work of wrought iron. The great spans, each of which has one end resting on two of these columns, are made on the principle of a double bow; the lower one is of chains, carrying the roadway; the upper is a tube of wrought iron, to which the lower is attached by powerful supports. Thus, a great weight on the lower bow only tends to give additional support by strengthening the upper, and *vice versâ;* each, in fact, counteracts the effect of the other. Each arched tube is elliptical in form, and made throughout of inch boiler-plate, with inside wrought-iron diaphragms, with tie-rods and angle-irons. The pressure on the centre pier foundation is more than eight tons to the foot; the whole work involved six years' toil, anxiety, and peril. The Chepstow Bridge has a span of 306 feet, besides three side spans of 100 feet each.

TECHNICAL DRAWING.—LXXIII.

DRAWING FOR BRICKLAYERS.

In addition to the positions already mentioned, brick arches are also used under the following circumstances:—

When the whole or part of a front is to be covered with cement, straight arches are sometimes built rough in the following manner:—At the key or crown of the arch fragments of bricks are laid, cut to the form of the letter V. All the others are whole bricks, parallel sided, but diverging inwards in contrary directions, and cut at top and bottom only to the splay. This can scarcely be said to carry out the arch principle, and is not by any means to be recommended. Inverted arches are generally used in bad or doubtful foundations, and often even in good foundations, immediately under the apertures of the doors and windows. These may either be segmental, semi-circular, or parabolic.

In storehouses, stables, etc., where much light is not required, semi-circular openings are sometimes made arched at top, with a sill at the bottom.

In the basement storey of buildings small circular apertures, technically termed "bull's-eyes," are sometimes made, which are arched all round, so as to possess the properties both of common and inverted arches. These, however, seldom exceed three feet in diameter.

Rough arches are often used to support the flues of chimneys, whenever it is required to change the direction of those flues, in order that those belonging to distant fireplaces may be brought up in the same shaft at the top of the house.

Arches for coal-cellars, etc., are often built opposite to the basement storey of houses, beyond the area, so as to extend below the pavement of the street. These arches are commonly semi-circular, one brick thick, not exceeding nine feet in span, and having pier walls of one and a half or two bricks in thickness—that is, when there is a continued range of them; they being supported at the extreme ends by abutments of greater thickness when necessary.

In plan the pier walls of such arches usually serve to support horizontal arches, forming the extreme ends of the same vaults, which are thus enabled to resist the pressure of earth of the

street or external ground. Arches of this description may be seen in the side walls of the Metropolitan Railway.

DRAINS AND SEWERS.

The purpose of these lessons precludes our entering further into this subject than to describe some of the forms of drains used for carrying off sewerage, and our illustrations must necessarily be limited to such as are constructed of bricks to the exclusion of drain-pipes formed of earthenware.

From every water-pipe carrying off rain-water from the roof of a building, as well as from every sink and water-closet, a small drain leads into a greater one, the former of which is called a branch drain, whilst the latter is called the principal drain of the building. The latter likewise receives the water from all the areas, and also often from the grounds in the immediate vicinity of the building, which for this purpose is levelled at a gentle slope, and has surface-drains or gutters leading to iron gratings over the main drains by which the water descends after rain.

Branch drains when built of brickwork are of three kinds:—

1. Flat at the bottom, with perpendicular sides and arched at the top, like the section of a small gallery. This kind of drain is built of various sizes, from 9 to 24 inches wide. In the first, three courses of bricks would be employed, the walls and arch being $4\frac{1}{2}$ inches thick; in the latter the walls would, as a rule, consist of eight courses, the custom being to make the height to the springing correspond with the width. The arch, as explained in a former lesson, would be formed of two concentric rings, $4\frac{1}{2}$ inches each.

2. The barrel or circular drain. The smallest size used is 9 inches in diameter, which is built with a 4-inch arch. This size is considered sufficient for carrying off clean water.

Barrel, or, as they are sometimes called, gun-barrel drains, are the best in exposed situations, because of their strength; but as, unless by some special construction, there is no mode of cleaning them without breaking them up if they are too long to be raked, they should not be employed except with a considerable fall and a frequent or constant stream of water through them, as from a pump, trough, rain-water tank, etc. They are constructed on a barrelled centre, which the bricklayer drags on as he advances with his work, finishing as he goes.

In this, as in all small arched forms when built of the rough bricks, the joints must necessarily open very wide at the extrados or outer ring, for the reasons previously stated. Hence in the drains at the Ordnance Barracks at Chatham the bricks were ordered to be cut and gauged. When this is not done, pieces of broken bricks, tiles, etc., should be put between the bricks at the outer ends of the joints instead of using all cement or mortar.

In barrel drains of larger diameter, the circular arch is formed of several $4\frac{1}{2}$-inch concentric rings of brickwork. The slope of a drain for clean water may be from $1\frac{1}{2}$ to 2 inches in 10 feet: the slope for a drain carrying down other sewerage should be from 2 to 3 inches in 10 feet, where such a slope can be commanded. The barrel form is that generally adopted for small drains, for which there seems to be good reasons, as the circle is the most compact and strongest form, and gives greater velocity, or, as it is termed, a sharper run to the water than a flat-bottomed drain of the same width.

All sewers, in fact, which are intended to convey anything more than water should either be cylindrical, or be built with concave bottoms, although the sides be parallel and the covering horizontal. The concave channel keeps the stream more together, and better enables it to carry its impurities along with it; whereas a flat-bottomed drain offers a large surface for the particles of soil to attach themselves to; and further, the stream of water being more scattered is less efficient in force.

Drains, in places where it may be necessary to open them at any time, should be somewhat of the form of the letter U, semicircular at bottom, and raised for a few courses above the inverted arch; the whole being covered with a flat stone. The obvious advantage of this arrangement is that the drains may be opened and examined without materially deranging the work; whereas the small drains constructed wholly of brickwork cannot be thus examined without taking the upper part of the arch to pieces.

In all small drains, except those for clean water only, it is necessary to have cesspools considerably larger and some feet deeper than the drain or drains to which they belong.

These cesspools being covered by a stone or iron plate, or sometimes by a grating, receive the sand or earth washed down, and thus prevent the drains from being choked up; and when the cesspools themselves are nearly full, which should be ascertained by the persons in charge of the building, they must be emptied out by removing the stone or iron covering, which is replaced after the clearing is effected. Besides these cesspools, it is usual to form much smaller ones of a different description, usually termed "stink-traps," to prevent offensive smells from passing along the whole extent of a drain. They are made by forming part of the bottom of a drain at a lower level, so that water must necessarily stand in it at all times, although the body of the drain may be occasionally dry.

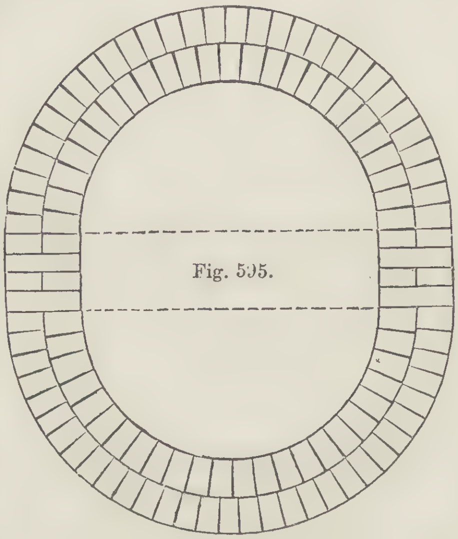


Fig. 595.

Into the little pool of water thus formed a vertical stone or plate of iron is fixed from above, the under part of which enters lower than the surface of the water. This arrangement, without impeding the regular course of water in the drain, which finds its level after entering beneath this stone or plate, prevents in a very great measure the passage of foul air.

These traps are now made of iron or earthenware, and should be well studied by the bricklayer, so that he may understand their action.

Care should be taken in arranging the small drains of a building that nothing but the clean water drains shall have any possible communication with the tanks or cisterns for receiving rain-water from the roofs when such are used.

When the principal drain of a building is within a few feet of the surface, it may be formed of bricks or earthenware pipes large enough to carry off with ease the greatest quantity of water that can come from the branch and surface drains.

This arrangement is not, however, always practicable. In every building having a basement storey it becomes a necessity that the bottom of the drain should be below the level of the area. In this case, but more especially where the drains pass under pavements, roads, walls, etc., which cannot conveniently be disturbed, it is proper to make them large enough for a man to go through and examine any part of it. Drains of this description are termed sewers or culverts, to distinguish them from the smaller kinds before described. The smallest sized opening in which a man can well move by stooping is one of $2\frac{1}{2}$ feet in width by $3\frac{1}{2}$ feet in height.

Such sewers may be elliptical in section, oval, or egg-shaped—*i.e.*, wider at top than bottom—or they may have vertical sides with semicircles or arcs at top and bottom.

Fig. 595 is a section of a drain of the kind last mentioned. In this example it will be seen that the walls of the drain are one brick in thickness, the upper and lower arches being formed of two $4\frac{1}{2}$-inch rings. These are formed of bricks laid on edge, and are not rubbed to the splay, which is not deemed necessary in arches of this character and span.

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THE

TECHNICAL EDUCATOR:

BEING THE TECHNICAL SERIES OF "CASSELL'S POPULAR EDUCATOR."

THE LATHE.—X.

By Henry Northcott.

LIGHT HAND-TOOL LATHES (*continued*).

Fig. 31 is another example of a light hand-tool lathe with slide-rest attached, as made by Messrs. Cunliffe and Croom, of Manchester. This lathe also is a good example of its kind, well and substantially made, and possessing one or two features that have not been yet illustrated in any of the lathes of which engravings have been given. The driving-shaft has outside cranks, which are connected to the treadle by chains. The shaft itself is turned throughout its length, and instead of being hung between the points of two centre-pointed screws with lock-nuts, or supported in solid bearings, it is arranged to run upon friction rollers. There are three of these small rollers at each bearing. Two of them are placed underneath the shaft to form the proper bearing, and the third is placed over the shaft to keep it in place and prevent it rising. The bearings of the shaft are thus formed by six of these rollers or pulleys, and these pulleys are caused to rotate slowly by frictional contact with the shaft when the latter is put in motion. The object of this arrangement is the reduction of friction. By it and the use of chains—which also have a rolling motion—the crank-shaft may be rotated with great ease. When the inertia of the heavy fly-pulley is overcome, and the shaft put into rapid rotation, the rotation will continue for a long time after the primary moving force of the foot has been withdrawn from the treadle-board.

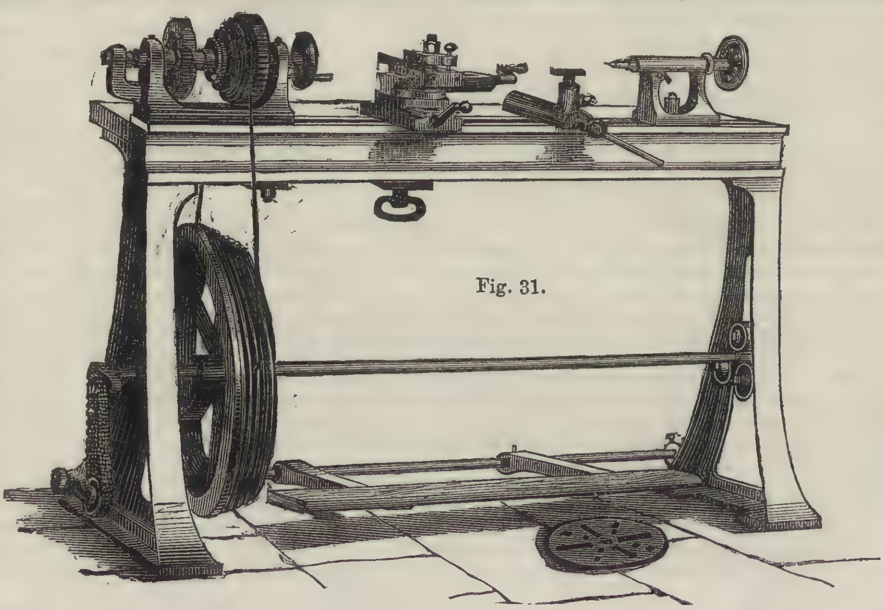


Fig. 31.

The slide-rest is of the same general construction as some of those already illustrated, and it is fastened down upon the lathe-bed in the same manner as in the previous examples—namely, by means of a bolt fastened to the bottom of the rest, and passing down between the slabs of the lathe-bed, with a suitably shaped hand-nut underneath. Generally the hand-tool rest is fastened down in the same manner, but in the present example another mode is adopted. It will be noticed that there is no handle underneath this hand-tool rest, but a lever is shown attached to a spindle projecting from the front of the rest. This spindle, after passing through a bearing formed by the metal of the rest, is made excentric, and the excentric portion goes through a circular eye upon the holding-down bolt. By raising the end of the lever shown in front, the centre of the excentric portion of the spindle is shifted downwards towards the bolt, which is thus loosened, so as to allow of the rest being moved along the lathe-bed. By forcing the end of the lever downwards, the centre of the excentric is raised, and the bolt is tightened up so as to fix the rest firmly upon the bed, as is necessary when the rest is to be used. This is a somewhat neater plan than the other, and it is occasionally applied to the shifting headstock also. Its chief advantage is its not interfering with the transverse ties, or stiffening pieces which generally connect the two slabs of the lathe-bed. In long beds these connecting webs are very necessary to keep the two slabs in position, and to stiffen them. The through-bolt with the handle underneath evidently interferes with the movement of the rest along the bed if the transverse ties are used. For short lathe-beds one kind of fastening is as convenient as the other, but the long bolt with the hand-nut under is evidently inadmissible in certain cases, whereas the short bolt and excentric can always be applied. It will not be necessary to describe any other lathes of this kind, as there is a very strong family likeness amongst them, although some details are differently worked out according to the fancy or opinion of the maker. Some have back-gearing, and some have not; some have outside cranks, and some have inside cranks; some are fitted with slide-rests, and some are not so fitted. But however the crank-shaft may be arranged, it should run easily and truly. All the power absorbed in driving the crank-shaft, lathe-spindle, and other mechanism is not only so much power exerted without producing any useful effect, but the power thus abstracted is actually employed in wearing out the lathe mechanism. It is very necessary, therefore, that every means should be taken to reduce friction, not only by correctly proportioning the bearing surfaces and fitting the lathe with proper lubricating apparatus, but by keeping them well oiled and free from dust, grit, and hardened oil. For the proportions of the lathe and means for lubrication the lathe-maker is responsible, but for the remainder the lathe-user is alone responsible. By using good oil, and not too much of it, and keeping the bearings clean, a good lathe will give satisfaction and continue in good order for a lifetime. But a careless turner may ruin his lathe in a few months. Turners should always bear in mind that all the force required, otherwise than to cut the material, is worse than wasted; and

that the physical exertion and fatigue corresponding to this, is being employed in destroying the lathe.

It is very advisable also that the rotating parts of a lathe should be accurately balanced, and this is especially the case with light lathes, which are driven at a high velocity. The driving-wheel is sometimes purposely made heavier on one side so as to overbalance the weight of the treadle and connecting gear, and prevent the crank stopping on the centres. In this case a greater evil is obviated than is introduced, as the driving-wheel does not run at a very great velocity. But the driving-arm of the dog-plate, or the connecting bolt for the double gearing, when unbalanced, will in fast-running lathes cause considerable vibration of the whole lathe, and render the production of good work a matter of impossibility.

Fig. 27 (Vol. III., p. 313) shows the kind of hand-lathe chiefly employed by engineers, and these are driven from overhead in the manner already explained. Sometimes, where many are used, they are mounted several upon one long iron bed, instead of on separate beds as in the figure. The counter-shafting is also placed in a line overhead, and the belt-shifting levers are generally brought down and connected with a long horizontal rod placed in front of the lathe-bed, so as to be within reach of the workman, wherever he may be standing at his work. In the early days of mechanical engineering all the work had to be turned in hand-lathes, and turning was often a very tiresome and laborious occupation. But now the hand-lathe is reduced to a very subordinate position in the workshop, being chiefly employed in preparing work for self-acting lathes, and in completing the shape of such odd and inaccessible corners as the self-acting lathes cannot so conveniently operate upon. The old school of millwright hand-turners is now very nearly extinct, but I have heard members of it say that those who attend to self-acting lathes are not turners at all, and even maintain that the work they produced in their youths was equal both in quality and quantity to that produced by the aid of the self-acting lathe. Neither of these statements will bear much investigation, but I have worked with and known hand-turners, not only in wood but in metals, who could run a self-acting turner a very close race in certain classes of light turning which are now almost exclusively executed in self-acting lathes.

The hand-lathe is adapted to plain turning in any material. The materials chiefly used are woods of various kinds, iron and brass, and not only does each of these substances require different tools and different treatment, but each material varies so much in texture and density as to require corresponding variation in the means employed in working it. Wood, for instance, may be obtained of very different densities. Some of it is readily indented, and may almost be cut by the finger-nail; other varieties are almost as hard and quite as difficult to turn as some of the metals. The tools suitable for cutting the softer varieties of woods would be greatly damaged if used upon some of the hard woods, and if the hard-wood turning tools were employed upon soft woods the result would be equally unsatisfactory, although in this case the tools would have the best of the encounter. Iron, again, if of good quality, is comparatively soft, and some varieties are so soft that they may be acted upon by tools which would produce a fair result even upon soft woods. Other sorts of iron are much less tractable, and cast iron requires quite different treatment to that suitable for soft wrought iron. Steel, if well annealed, is as soft and as easily turned as good wrought iron. If improperly annealed it may require much the same tools and treatment as cast iron, or it may be so intractable as to be a most difficult and unsatisfactory substance to deal with. Hardened steel, or steel that has been made red hot and suddenly cooled by immersion in cold water, is quite invulnerable so far as cutting is concerned, although it may be shaped by other means.

Brass also exhibits very similar properties. As a rule it may be turned in much the same way as good cast iron; but whereas soft brass may be ripped off with ease and rapidity, hard brass is very nearly as intractable as hardened or partially hardened steel. Ivory and some other materials of similar texture chiefly used for ornamental work are operated upon by tools of much the same character as some of the hard woods.

Copper, lead, and zinc are not much employed for turned articles. They are easily turned with the tools suitable for wrought iron, and require no very distinctive treatment.

The softer fibrous woods require very keen tools, with a cutting edge formed with a very acute angle. For the denser woods the angle must be much more obtuse, although the cutting edge should still be kept keen and well sharpened. As a general rule, the softer the material the more acute should be the angle of the cutting tool.

Then again, not only must the cutting tool be adapted to the nature of the material it is required to operate upon, but the speed of cutting must be similarly varied. The soft wood may be driven at a very high velocity whilst being turned, and within certain limits the faster the speed the smoother and more satisfactory does the tool cut. For iron and well-annealed steel the speed must be considerably reduced. The surface to be cut should not pass the tool's point at a much greater velocity than eighteen feet in a minute. Cast iron is usually driven somewhat slower than this, and brass and lead rather faster. The harder the material the slower must it be driven past the cutting tool. The operator soon gets to know how fast he can advantageously drive his work, as if the speed be too great his tools rapidly lose their cutting edge, and if the excessive speed be continued the temper of the tool is injured, owing to the great heat developed by the friction caused by the tool's rubbing against the work instead of cutting it. An experienced turner can tell at a glance whether the speed is correct for the material he wishes to cut, but the beginner requires to exercise a good deal of care if he wishes to keep his tools in proper order.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIII.—NICHOLAS COPERNICUS.

BY JAMES GRANT.

In Vol. II. of The Technical Educator it has been shown how Galileo, in the sixteenth century, was the first who taught physics to speak the language of truth and reason; but it was a little before his time that Nicholas Copernicus discovered the true system of the world, and invented that method of astronomy which still bears his name.

He was born on the 10th of January, 1472, in the quaint old town of Thorn (in Polish Prussia), which twenty years before had revolted against the tyranny of the Teutonic knights, and been incorporated with the kingdom of Poland. He was taught Latin and Greek at home, but afterwards was sent to Cracow, to study philosophy and physic at that famous old university which had been began by Casimir the Great, and finished by Udislaus Jagello. In his twenty-third year he set out for Italy. His genius had now turned to mathematics, which he studied in all its various branches; thus he stayed for a time in Bohemia for the sake of being with the celebrated astronomer, Dominicus Maria, whose society he cultivated, less as a learner, than as an assistant to him in making his observations. From Bohemia he proceeded to Rome, where he speedily won a reputation that was considered no way inferior to that of the famous Regiomontanus; and his name became so famous, that he was chosen professor of mathematics, which he taught for a long time with great applause, during the stormy period when Pope Alexander VI. occupied the chair of St. Peter.

In the year 1500 he made some important astronomical observations at Rome, and on returning to his own country he began to apply his vast knowledge in mathematics to correct the system of astronomy which then prevailed. He set himself to collect all the books which had been written by philosophers and astronomers—no easy objects of acquisition in the first years of the sixteenth century—and to examine all the various hypotheses they had invented for the solution of the celestial phenomena, seeking thereby if a more symmetrical order and constitution of the parts of the world could not be discovered. Of all the hypotheses of the ancients, none pleased him so well as the Pythagorean, which made the sun the centre of the system, with the earth and planets revolving round him in their own orbits.

Many of the ancients, he found, had maintained this idea; particularly Ecphantus, Seleucus, Aristarchus, Philolaus, Cleonthes Samius, Nicetas, Heraclides Ponticus, Plato, and, lastly, Pythagoras. Archimedes also, in his book of the number of the grains of sand, had maintained the Pythagorean system, but until the days of Nicholas Copernicus it was dropped and forgotten. After long and profound contemplation, and after

many calculations, the learned Pole removed some of the obscurities of the old system and improved it. These discoveries and improvements he embodied in a work on astronomy, the publication of which, knowing the perils that then surrounded those who dared to broach new opinions, he with great prudence suppressed, until he found a powerful lover of astronomy to protect him in the person of Pope Paul III., a learned, bountiful, and magnificent prelate—the same who boldly cited Henry VIII. of England to appear before the College of Cardinals, there "to answer for his adultery and other crimes."

In this system none of the celestial bodies shine with their own native light, save the sun; so that all the planets, both primary and secondary, are opaque bodies, that have no other light but that which they receive from the sun, and reflect back towards the earth and other planets. This is most evident from the moon; for only that side of her is observed to shine, which is directly opposed to the sun; while the other side which is turned from the sun is quite dark, except so far as it is illuminated by reflection from the earth. We see her, indeed, more or less illuminated in proportion as more or less of the surface on which the light of the sun is shed is turned towards the earth, as is evident on watching her through her various phases. Thus at the full she appears all illuminated, and at the change all dark. The same phenomena are observable in Venus and Mercury, which show all the phases of the moon, and sometimes appear like a black spot upon the luminous body of the sun. Mars likewise appears gibbous when near the quadratures of the sun. The satellites of Jupiter are eclipsed when they are behind his body, being then lost in his shadow; they likewise cast their shadows on the body of Jupiter. In Saturn the shadow of the ring upon his body proves his opacity; while the weakness of the light of those planets which are remote from the sun shows that it is not innate, but borrowed.

All the planetary bodies, Copernicus maintained, were nearly spherical, and that all of them had a rotation round their axis. These motions are found by means of certain spots upon their surfaces, which fix the time of their rotation. In some planets, from the absence of such indications, the times of their revolution have not yet been found. That they are spherical bodies appears from the slow motion of the spots near their edges, and their swifter motion near the middle. Likewise the line separating the illuminated part from the dark is always elliptical, which proves their form to be spherical.

Such was the system of Copernicus, who so fully revived that of Pythagoras, and thus inaugurated a new and important epoch in the history of astronomy, which we may justly reckon the most ancient science in the world, for Josephus tells us that Seth erected two pillars, one of stone and the other brick, whereon were graven the principles of that science.

In the dedication of his labours to Pope Paul III., Copernicus tells his holiness, that "he had suffered the fruit of his labours to ripen, not nine years only, but four times nine."

At length he committed the care of the impression to two friends named Schoner and Osiander in a distant city, where the work was printed in 1543, under the title of "De Revolutionibus Orbium Cœlestium," and the author, then residing at Frauenburg, a little town on the shores of the Haff, not far from Kœnigsberg, received a copy of it but a few hours before his death, which occurred on the 24th of May in the same year.

He resided in a house near the cathedral (of which he was a canon), and in the latter, a handsome building on a height overlooking the town and the Haff, he was buried; and there are still preserved, besides his tomb—a simple tablet bearing a globe—some curiosities and relics, such as crucifixes, and other things which belonged to him.

Within the enclosure of the cathedral is a well furnished with water by an aqueduct and hydraulic pumps constructed by him. The machinery of these pumps has, of course, long since disappeared; but a model of it is still preserved in the cathedral, and is supposed to have been imitated in the water-works at Marly. The tower which contained it stands near the cathedral, and is called the *Kunst Thurm.*

Besides supplying the Domberg (or cathedral hill) with water, he introduced it into the town of Frauenburg, by collecting from the neighbouring streams a current of water sufficient to turn a corn-mill, an advantage which its inhabitants did not previously enjoy. On the southern wall of the *Kunst Thurm* there is still traceable the following inscription to the memory of Copernicus:—

> "Hic patienter aquæ sursum properare coactæ,
> Ne careat sitiens incola montis ope.
> Quod Natura negat, tribuit Copernicus arte;
> Unum pro cunctis fama loquatur opus."

Few works that the world has seen have destroyed more riveted and deeply-rooted errors, or have established more important truths, than the great book of Copernicus. His noble theory, now so well known as the Copernican system, was at first coldly received, or utterly rejected; but the labours of future astronomers at length obtained for it complete triumph. Copernicus was also the first who demonstrated the double orbit of the moon—her menstrual motion about the earth, and her annual about the sun. Nor did this great man stop here; for after laying a solid foundation of the celestial physics, he began the superstructure, by surmising a principle of attraction to be inherent in all matter.

Copernicus also wrote a tract on trigonometry, and has also, as we have shown at Frauenburg, exhibited tokens of the versatility of his talents. He was very familiar with the Greek and Latin languages, and was acknowledged to have considerable skill as a painter.

In 1616, when Paul V. occupied the pontifical chair, seven inquisitors passed a decree at Rome, declaring that the opinions of Copernicus, as demonstrated by Galileo, were *not only heretical in faith, but absurd in philosophy.* "This sentence," says Voltaire, "against an opinion which has since been so variously confirmed, is a pregnant testimony of the force of prejudice. It should be a lesson to those who have nothing but power on their side, to be silent when philosophy speaks, and not to attempt to determine points which do not fall under their jurisdiction."

Galileo, as we have shown in his memoir, was condemned by the same severe tribunal to do penance in prison, and to retract on his bended knees! And it is a curious fact, and perhaps not generally known, that the Papal excommunication of Copernicus for publishing his "System of the Revolution of the Heavenly Bodies" was not revoked until 1821!

His name is still borne by an astronomical instrument invented by Whiston, to show the motion and phenomena of the planets, both primary and secondary. It is founded upon the Copernican system, and therefore is called by his name.

FARMING AND FARMING ECONOMY.—XV

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

BREEDS OF CATTLE (*continued*).

HEREFORDS—DEVONS—SUSSEX—LONG-HORNS—NORFOLK AND SUFFOLK—WELSH BREEDS—GALLOWAYS—ANGUS OR ABERDEEN—WEST HIGHLANDERS—AYRSHIRES—IRISH CATTLE.

To give a minute and graphic description of an animal is by no means easy, and in the remarks which follow we shall endeavour to give only a general idea as to the appearance, character, distribution, and history of the remaining races of British cattle.

Hereford Cattle are principally found in the south-west of England, and, according to the late Mr. H. H. Dixon, few counties south of Shropshire are without them. They are to be seen grazing on the rich marshes of the eastern counties, and have pushed their way into Surrey on the south-east, and Cornwall on the south-west. They are seldom seen in the north of England, and we only know of two herds in Scotland. They have met with supporters in Ireland, and a considerable export trade exists in breeding animals to Jamaica, Canada, the United States of America, and Australia. Although four varieties of Hereford cattle are described—the red with white faces, the red with mottled faces, the light greys, and the dark greys—the first is the most ordinary type. They are all large and imposing in appearance, and are of a fine red colour, broken with white upon the breast, face, mane, ridge of back, end of tail, and occasionally on the feet. Their fattening propensity at mature age is quite equal to that of Short-horns. Doubt has, however, often been thrown upon their flesh-producing powers at from two to three years old. That this is founded on fact is, however, questionable. But in order to throw light upon an important question, we abstract the following table from the *Agricultural Gazette* of December 17th, 1870,

where not only the average weight and ages of Short-horns and Herefords are given as obtained at the Islington show of that year, but also the average weights of Devon and Sussex cattle. The result obtained by the scales was as follows for oxen :—

OXEN.	No. of Class.	Average Age.		Average Live Weight.		
		yrs.	mths.	cwt.	qrs.	lbs.
Devons	7	2	4	10	0	20
Herefords ...	6	2	4½	14	1	13
Short-horns ...	4	2	4	15	3	0
Devons	8	3	2	13	2	22
Herefords ...	4	3	0	15	3	1
Short-horns ...	5	2	11¾	17	0	18
Sussex	4	2	9	15	0	6
Devons	8	4	1¼	16	0	26
Herefords ...	13	4	0¼	19	2	23
Short-horns ...	9	3	10½	18	3	10
Sussex	7	3	10¼	19	0	12

Lord Scudamore, who died in 1671, is recorded as having introduced red cows with white faces from Flanders, and from these, the calf in question, as well as others—for we can hardly give credit to the assertion that all the "white faces" are descendants of one bull—may have derived their colours. The Herefords, like the Short-horns, have a history. Their improvement was due to the labours of the Messrs. Tomkins, Weyman, Yeoman, Tully, and Hewer, from about the year 1766. Since then the breed has been carefully kept up, and the pedigrees of pure-bred animals have been preserved in a Herd Book commenced in 1845 by Mr. Eyton, and continued since 1857 by Mr. Duckham, of Baysham Court, Ross.

The *Devon Cattle* form a well-defined race of uniform red colour, and of smaller size than Short-horns or Herefords. They are supposed by competent naturalists to be nearly allied to the modern type of *Bos primigenius*, seen in Chillingham Park, and therefore claim a direct descent from the ancient bovine inhabitants of the British forest. The breed is divided into the smaller and more symmetrical, mossy-coated, North Devon, and the larger, straight-haired cattle of the fertile vale of Taunton Deane. The breed has not extended widely in this

AYRSHIRE COW.

while the comparison of the cows by weighing presented these adjoined results :—

Cows.	No. of Class.	Average Age.		Average Live Weight.		
		yrs.	mths.	cwt.	qrs.	lbs.
Devons ...	4	3	1¾	13	3	14
Herefords ...	5	3	4½	14	0	8
Short-horns ...	10	3	1¾	16	0	12
Sussex... ...	8	3	5	14	3	0
Devons ...	4	6	11¾	12	1	19
Herefords ...	6	6	6	16	2	5
Short-horns ...	6	7	8½	18	1	23
Sussex... ...	4	6	4	15	2	24

Mr. Duckham, editor of the "Hereford Herd Book," contests for the superiority of his favourite breed, and informs us through the columns of the before-named paper (May 21st, 1870) that at the Christmas meeting, 1868, the average weight of the Hereford steers not exceeding 2 years 6 months old was 10 st. 3 lbs. more than that of the Short-horns; whilst in the class not exceeding 3 years and 3 months old he is compelled to admit that the Short-horns exceeded the Herefords by an average of 5 stones (14 lbs. to the stone).

The beef of Hereford cattle is of fine marbled appearance, and of excellent quality, but the cows are poor milkers. The race is said to have been of uniform reddish-brown colour until the appearance of a white-faced bull calf about the middle of last century, from which the present Herefords are descended.

country, and is for the most part in the hands of a less wealthy class of men than the short-horn. Captain Tanner Davy, their historian, and the editor of the "Devon Herd Book," however, assures us that they have found a home in many counties of the United Kingdom, as well as in Mexico, Jamaica, Canada, Australia, France, and the United States. The general colour of the Devon cattle is red broken with white upon or near the udder only. The skin is of an orange-yellow colour, as is seen around the eyes and inside the ears. The horns are of medium length, and of fine waxy colour. The general form is light and graceful, but scarcely so good in the posterior as in the anterior portion of the body. The cows are famous rather for the richness than for the abundance of their milk. The Devon oxen are better adapted for the yoke than any other British race, and a pair of bullocks will plough in double harness, as the writer has himself seen. The *Sussex* cattle are very nearly allied to the Devons. They are stronger and coarser in head and horn, and larger in frame, but in all other points are identical with the Devons.

The *Long-horns* are chiefly interesting as a race which, after having been improved by the breeder's art, and introduced as the leading breed into almost every English county, has succumbed to a powerful rival whose very name appears to have been coined in a spirit of opposition—the Short-horn. These cattle originally were found by Bakewell in the fertile vale of Craven, in the West Riding of Yorkshire and eastern portion of Lancashire. Mr. Welby and Mr. Webster, of Canley, both obtained their stocks from Sir Thomas Gresley, of Drakelow

House, and this strain of blood subsequently came into the hands of the famous Leicestershire breeder, who, keeping in view the importance of beauty and utility of form, muscular development, and fattening qualities, brought out the new Leicesters, which soon became the favourite cattle of their day. They are thus described by Youatt. The fore-end long and light almost to elegance; neck thin; chap, or under side of jaw, clean; the head long, fine, and tapering. Horns varying according to sex; in the bull from fifteen to twenty-four inches, and in the cow and steer from thirty to forty-two inches in length; the horns turning down almost parallel with the cheeks, and in some cases turning inwards so as to require cutting, to prevent them from piercing the face of the animal. The colour, white along the back, and brindled brown and black on the sides. The Long-horns were imported into Ireland by Lord Massereene, the Marquis of Donegal, and Mr. Lesley, of Lesley Hill, and did much to improve and modify the native breeds of cattle there. They were also naturalised in Anglesea, where their descendants, still preserving the most characteristic traits of the breed, are yet to be found. Long-horns are still to be seen in the Midlands, and we may especially mention Mr. Chapman's herd at Upton, Warwickshire, as preserving the blood of the renowned bull "Twopenny."

Norfolk and Suffolk possess an excellent breed of polled, red cattle, supposed to have been derived from the polled Galloway cattle which have for long been favourites with the eastern counties' graziers. These animals are of uniform red colour, and are excellent milkers.

HEREFORD COW.

WEST HIGHLAND COW.

WELSH CATTLE.

Pembrokes.—These cattle are closely allied to the aboriginal cattle of this country; the White Forest breed, by mere change of colour, becoming similar to the modern Pembrokes (*Lowe*). The colour is black, broken upon and about the udder with white; the horns are fine, tapering, turned up at the points, and tipped with black; the skin is of a deep orange colour, sometimes approaching to black, as is seen on the naked portions of the body. The Pembroke may be looked upon as the type of all the mountain breeds of Wales, although he often appears as an unimproved and inferior type.

The Glamorgans have been crossed with the Herefords, to

which they now bear a strong resemblance. The cattle of Anglesea retain the appearance of the Long-horn, with which they were crossed during the dominance of that race.

SCOTCH BREEDS OF CATTLE.

Scotland is rich in native races, many of which are very distinctive. Among them one of the most important is the *Galloway* breed, named after a district which forms the termination of a range of hills stretching from St. Abb's Head, on the east coast, to the North Irish Channel. It comprises Wigton and Kirkcudbright, and a portion of Ayr and Dumfries.

The Galloway cattle are black and hornless (polled), and on account of this last-named peculiarity, as well as their fattening properties, are great favourites with graziers, especially in Norfolk and Suffolk. The Galloway cattle are peculiar for a wonderful compactness of form, great length, uniform breadth from the shoulder to the rump, heavy well-fleshed thighs, and deep well-sprung ribs. They are not a large breed, but will often attain to heavy weights. Closely resembling the Galloway is the *polled* or *clodded Angus* or *black Aberdeenshire* race. They are higher on their legs, and altogether larger and somewhat less closely grown beasts than the last, with scarcely so much coat. They are black, occasionally broken with a little white near the udder; hornless; characterised by great length and great width across the shoulder-tops, continued backwards by well-sprung ribs, and good loins without prominent hook-bones. The hair is short and glossy, and the skin soft and thick. Such is a general description taken by the writer from prize animals exhibited last year at the Highland and Agricultural Society's Show at Perth.

The *West Highland Cattle* or *Kyloes* form a well-marked race occupying all the mountainous region after which they are named. They are small in size; have horns turning more or less upward at the points; short muscular limbs, and are thickly covered with hair. Their muzzle is usually black; the hair on the neck (mane) is long; their colour varies from mouse, or even silver grey, to reddish brown and black; they are hardier than any other race of British cattle, and their size varies according to the richness or poverty of the district in which they occur. The finest specimens are found in parts of Argyleshire and in some of the Hebrides, as in Skye.

Ayrshire Cattle are famous as dairy stock. Colonel Fullerton, in "The Husbandry of Ayrshire, 1793," says that Mr. Bruce, a gentleman of long experience, dates their origin to cows introduced by the Earl of Marchmont, who succeeded to his title in 1724, and died in 1740. The varied colour and other peculiarities point to the Holderness breed (the immediate progenitor of the improved short-horn) as probably the original stock which was crossed with the native breed, giving as the result the Ayrshires. These cattle are rather small in size, varying in colour from white with a little red, to red with a little white, and again from a fawn colour broken with white, to almost black and white.

The typical Ayrshire cow is formed for milk. Her long fine head and upturned horns are succeeded by a thin neck, no great depth of bosom, shoulder-tops and crops narrow, ribs well sprung, and great breadth over the hips. Again, looking at the broadside of the animal, the depth should gradually increase backwards towards the flanks, giving what is termed the wedge form. This is much insisted on by all Ayrshire breeders, and it signifies the gradual thickening of the animal from the set-on of the head, where the neck is light, to the base of the neck, the breast, the girth, and the still greater depth at the flank. This gradual deepening contrasts with the heavy fore-end of the short-horn, and indicates milking, rather than feeding properties. Milk is indeed their speciality. The cows will give five gallons per day for two or three months, three gallons for three months, and one and a-half gallons for four months. Mr. Aiton rates the annual yield of milk at 1,000 gallons, but Mr. Ranken considers from 700 to 850 gallons as rather more than an average cow will give.

IRISH CATTLE.

The droves of Irish cattle brought over to our fairs in such large numbers every year have rendered these hardy and useful animals familiar to the eyes of Englishmen. The late Professor Lowe says the native breeds of Irish cattle may be divided into those of the mountains, moors, and bogs, and those of the richer plains with intermixed breeds resulting from the union of different races. Among the most distinctive of these mountain cattle is the Kerry breed, good alike for milk and for beef. The *Kerry* cow, as figured in Professor Lowe's "Domestic Animals," is of a yellowish-red colour broken with white on the bosom, belly, and udder; the hair is abundant, and forms a tuft midway between the throat and dewlaps; the fore-quarters are light, and the whole frame of the animal indicates a disposition to produce milk rather than flesh; the neck is thin, the head fine and light; the horns white, tipped with black, and growing upwards. The Irish cattle have been modified by both the long-horn and the short-horn, and owing to the importation of the latter breed during late years, the general character of the Irish cattle has been much improved. Many pure-bred herds of short-horns also are to be found in Ireland, and this breed seems destined to spread over all the fertile portions of the country, as it has already done both in England and Scotland.

NOTABLE INVENTIONS AND INVENTORS.

XXXI.—ISAMBARD KINGDOM BRUNEL (*continued*).

BY JOHN TIMBS.

THE sea-wall of the South Devon Railway was another of Brunel's great works. On this line he adopted the plan which had been previously tried on the London and Croydon railway—namely, of propelling the carriages by atmospheric pressure; but this proved unsuccessful, and the loss exceeded half a million of money. Still, he entertained a strong opinion that this power would be found hereafter capable of adoption for locomotive purposes.

Next, Brunel devised an iron-plated armed war-ship, capable of withstanding the fire of the Sebastopol forts. It was in connection with the interests of the Great Western Railway that Brunel first conceived the building of a steam-ship to run between England and America. The vessel was built accordingly; its power and tonnage was about double that of the largest ship afloat at the time of her construction; it was propelled by paddle-wheels, and named the *Great Western*. Next, Brunel designed and built the *Great Britain* steam-ship, the result, as regards magnitude, of a few years' experience in iron ship-building, and more than double the tonnage of the *Great Western*. Brunel's foresight in extending the use of iron in the construction of ships was very remarkable. While others hesitated, he saw that it was the only material in which a very great increase of dimensions could be safely extended. The very accident which befell the *Great Britain* upon the rocks in Dundrum Bay showed the skill he had then attained in the adaptation of iron to the purposes of ship-building. The means taken, under Brunel's immediate direction, to protect the stupendous vessel from the injury of winds and waves attracted deserved attention, and they proved successful, for the vessel was again floated. Nor must it be forgotten that Mr. Brunel was the first man of eminence in his profession who perceived the capabilities of the screw as a propeller. From his experiments on a small scale in the *Archimedes* he saw his way clearly to the introduction of that method of propulsion which he afterwards adopted in the *Great Britain*. He next persuaded the Admiralty Board to give it a trial in Her Majesty's Navy, under his direction. He was much thwarted in this trial, but the *Rattler*, subsequently placed at his disposal, and fitted with engine and screw, by Maudslay and Field, was a complete success, and was the first screw-ship which the British Navy possessed.

Brunel built for the metropolis an elegant suspension bridge, from Hungerford Market to Belvidere Road, Lambeth—a fine specimen of mechanical skill. It consisted of two lofty brick piers or towers, in the Italian style, 58 feet above the road, and built in brickwork and cement, connected by inverted arches at the bottom, and built on the natural bed of the river, without piles. For the foundation of the abutments piles, 26 feet long, were driven in an inclined direction. In the upper part of these towers four chains passed over rollers, so as to equalise the strain; they carried the roadway seven feet higher than the crown of the centre arch of Waterloo Bridge, with single suspension rods, the chains being secured in tunnels at the abutments to iron girders, embedded in brickwork and cement.

There were three spans, the central one between the piers being 110 feet wider than the Menai Bridge, and second only to the span of the wire suspension bridge, which is 900 feet. Brunel's bridge was built without any scaffolding but a few ropes, consequently without impediment to the navigation of the river; the cost was £110,000. The bridge was taken down in 1863, and the chains were carried to Clifton for the suspension bridge erecting there. In November, 1843, the bridge was sold to the original proprietors for the sum of £226,000, but only the first instalment was paid, and the purchase was thus void. The height above the piers was 21½ feet. Thus was gained additional height for the river traffic and a graceful curve, with the appearance of swagging prevented.

During the Russian war Brunel fitted up the Renikoi hospital on the Dardanelles. He laid on a special supply of water from the adjacent hills, and constructed short lines of railway with easy carriages, to facilitate the removal of the wounded from the landing-place to the different wards.

In the year 1851, prepared by experience and much personal devotion to steam navigation, Mr. Brunel began to work out the idea he had long entertained, that to make long voyages economically and speedily by steam required the vessels to be large enough to carry the coal for the entire voyage, and unless the facilities for obtaining coal were very great at the outport, for the return voyage also; and that vessels much larger than any built could be navigated with great advantage from the mere effects of size. Hence originated the *Great Eastern.* "The mere idea of a ship of a capacity six or eight times that of anything afloat had doubtless occurred to many an enthusiastic schemer; but Mr. Brunel gave shape to his idea by preparing plans, and otherwise convincing himself of its practicability. As an example of naval construction the *Great Eastern* is, unquestionably, the work of Mr. Scott Russell; yet Mr. Brunel's services were hardly of less importance, and every one at all conversant with the organisation of an establishment devoted to the construction of steam-vessels is aware that the duties of the naval architect and builder and those of the engineer are each clearly defined, and in no way conflicting; and certain it is that Mr. Brunel's name will be indelibly associated with the *history* of the *Great Eastern,* as long as that shall survive."

The success of this stupendous work, in a practical point of view, is admitted, as well as the strength and stability of the construction of the vessel. The difficulties attendant on the launching of the ship in 1858 at one time seemed insurmountable. To a friend, who despondingly expressed his fears that the huge ship would never reach the water, Brunel quietly replied, "Oh, she shall move; she must!" He never for a moment despaired of success. His health, however, had long been impaired by over-exertion, and his death was hastened by the fatigue and mental strain caused by his efforts to superintend the completion of the great ship. By a coincidence, as it would appear, Mr. Brunel went on board the great ship for the last time on the day when it could be said she was ready for sea. If not so in every detail, she was, as a whole, essentially completed, although still untried. On that day, the 5th of September, Mr. Brunel was stricken down by paralysis, from which he never recovered. He sank until the evening of the 15th of September, when he passed away, still young, and upon the completion of the greatest work of his life.

In the Patents' Museum, South Kensington, is a model of the Leviathan Steamship, as it was first called, constructed on the wave principle and lines of Mr. Scott Russell, for the Eastern Steam Navigation Company. The following are the principal details:—Length, 680 feet; breadth, 83 feet; depth, 58 feet; tonnage, 23,000 tons; nominal horse-power of paddlewheel engines (Scott Russell and Co.), 1,000 horse-power; nominal horse-power of screw engines (Watt and Co.), 1,600 horse-power; draught of water (light), 18 feet; draught of water (laded), 28 feet.

Mr. Brunel died at his paternal house at Westminster. He was a Fellow of the Royal Society, having been elected at the early age of twenty-six. He was the President of the Institution of Civil Engineers, and Vice-President of the Society of Arts; a Fellow of the Astronomical, Geographical, and Geological Societies, and a Chevalier of the Legion of Honour. "He lived and died with a scientific reputation, bounded only by the limits of the civilised world. He has left too many monuments of himself, raised both on land and sea, to permit of his being soon forgotten."

In the *Quarterly Review* is the following estimate of Mr. Brunel's talents, which, it will be seen, differs from that of other authorities:—"Notwithstanding Mr. Brunel's great engineering skill, it is to be doubted whether he possessed much of the genius of an original inventor. He took up a principle already established, and pushed it farther, exhibiting in a striking light the development of which the ideas of others were capable. His ruling idea was magnitude: he had an ambition to make everything bigger than he had found it. Thus, he found the railway gauge 4 feet 8½ inches, and he increased it to 7 feet, thereby involving wider tunnels, more expensive works, and a heavier equipment in working stock. So in the atmospheric railway, he found the tube in use on the Dalkey Railway 15 inches in diameter, and on the South Devon line he doubled it. Then in steam-ships the *Great Western* was nearly double the power and tonnage of any previous steamer; the *Great Britain,* which followed, was double the tonnage of the *Great Western;* and the *Great Eastern* exceeded in size all that the most imaginative ship-builder had conceived to be possible. It was a race of bigness run against himself as well as others. But in the case of the *Great Eastern* steam-ship, as of the Great Western Railway, it is not probable that Mr. Brunel's example will be followed; for it is now pretty well understood that ships, like railways, may be *too big*—at least, for those who own them. Notwithstanding the want of success which attended Mr. Brunel's principal undertaking, he was well supported throughout by the moneyed interest. The shareholders in the Great Western Railway not only readily found the capital which he required to carry out his splendid ideas with reference to that line, but they presented him with a handsome testimonial in acknowledgment of his genius. Though the *Great Western* steam-ship proved commercially a failure, he had no difficulty in finding capitalists to enable him to build the *Great Britain* at a still greater sacrifice, and still again to project and bring to completion his magnificent idea of the *Great Eastern* steam-ship."

It may be interesting to abridge from the *Quarterly Review,* No. 223, already referred to, the following singular incidents of Mr. Brunel's personal history:—"He had more perilous escapes from violent death than fall to the lot of most men. He had two narrow escapes from drowning by the river suddenly bursting in on the Thames Tunnel works. During the Great Western Railway inspection he was one day riding a pony rapidly down Box Hill, when the animal stumbled and fell, pitching the engineer on his head. He was taken up for dead, but eventually recovered. One day, when driving an engine through the Box Tunnel, he discerned some light object standing on the same line of road along which his engine was travelling. He turned on the full steam, and dashed the object (a contractor's truck) into a thousand pieces. When on board the *Great Western* steam-ship he fell down a hatchway into the hold, and was nearly killed. But the most extraordinary accident which befell him was, in showing a sleight-of-hand to his children, his swallowing a half-sovereign, which dropped into his windpipe, remained there for six weeks, when it was removed through an incision in the windpipe by Sir Benjamin Brodie and Mr. S. Key; his body was inverted, and after a few coughs the coin dropped into his mouth. Mr. Brunel afterwards used to say, that the moment when he heard the gold piece strike against his upper front teeth was, perhaps, the most exquisite in his whole life."

SANITARY ENGINEERING.—XXIII.

ON THE CONSTRUCTION OF SEWERS AND SUBWAYS.

THE literature of sewer-building is so voluminous, extending to many volumes octavo in our public libraries, that anything approaching a complete analysis of the question is entirely beyond our limits. We shall content ourselves, therefore, in the present paper by stating a few general principles, and giving the details of the methods which are now generally adopted in some of the most important undertakings of the day. In our two preceding papers we dealt with house drainage (No. XXI.) and the ventilation of house drains (No. XXII.), and we now come to the next branch of our subject, *i.e.,* the commo

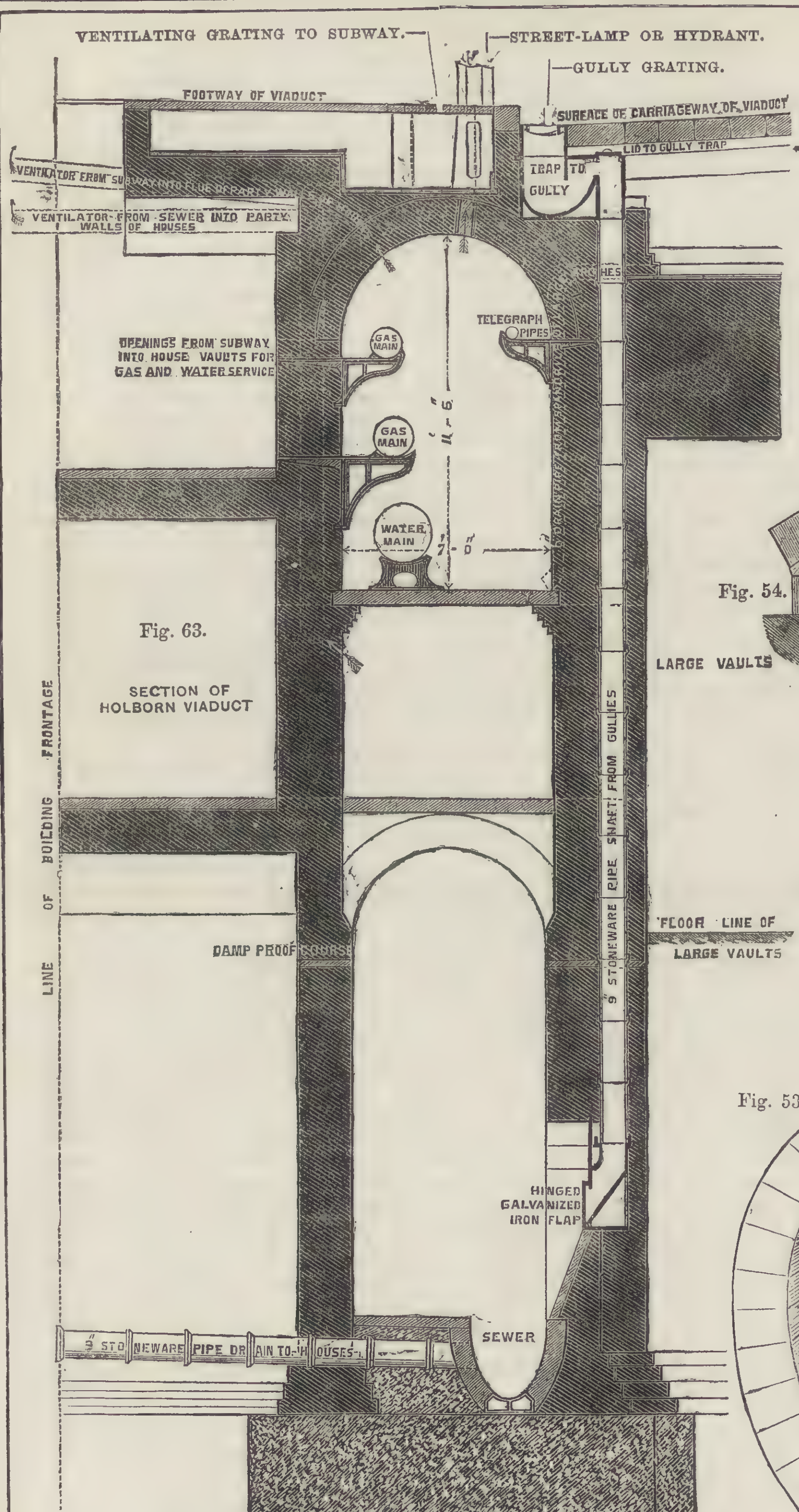


Fig. 63.

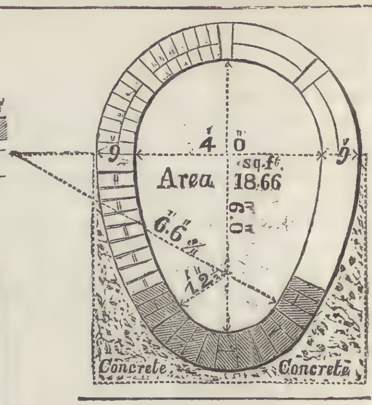


Fig. 56.—SEWER NO. 1.

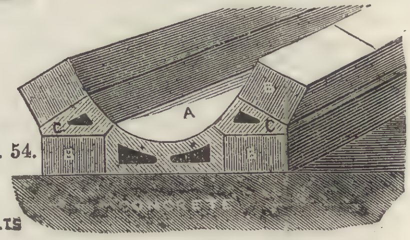


Fig. 54.

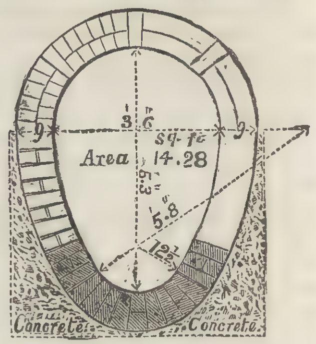
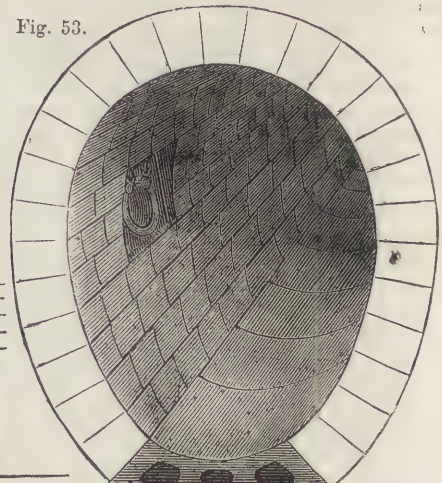


Fig. 57.—SEWER NO. 2.

Fig. 53.



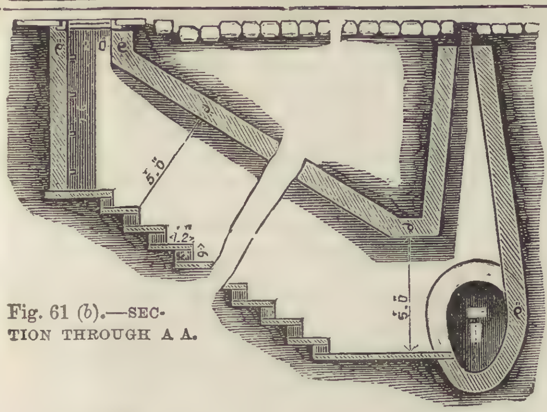


Fig. 61 (*b*).—SECTION THROUGH A A.

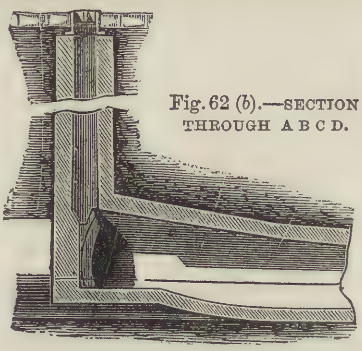


Fig. 62 (*b*).—SECTION THROUGH A B C D.

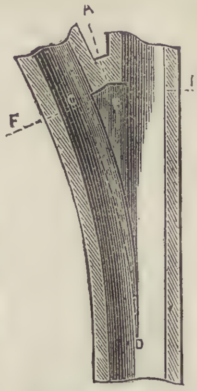


Fig. 62 (*a*).—BELL-MOUTH JUNCTION.

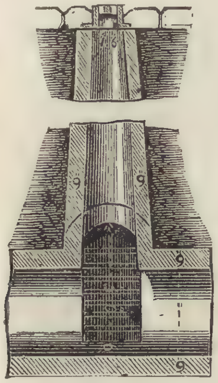


Fig. 61 (*c*).—SECTION THROUGH CC.

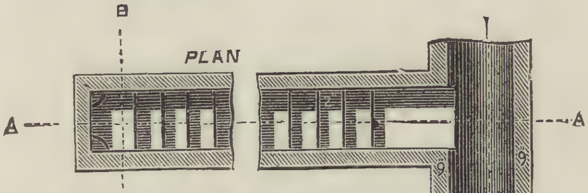


Fig. 61 (*a*).
SIDE ENTRANCE TO SEWER.

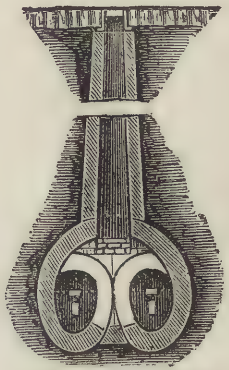


Fig. 62 (*c*)—SECTION THROUGH E B F.

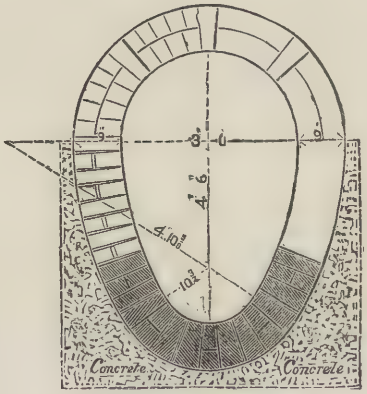


Fig. 58.—SEWER NO. 3.

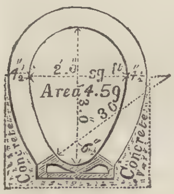


Fig. 60.—SEWER NO. 5.

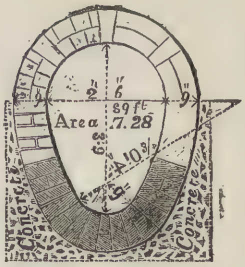


Fig. 59.—SEWER NO. 4.

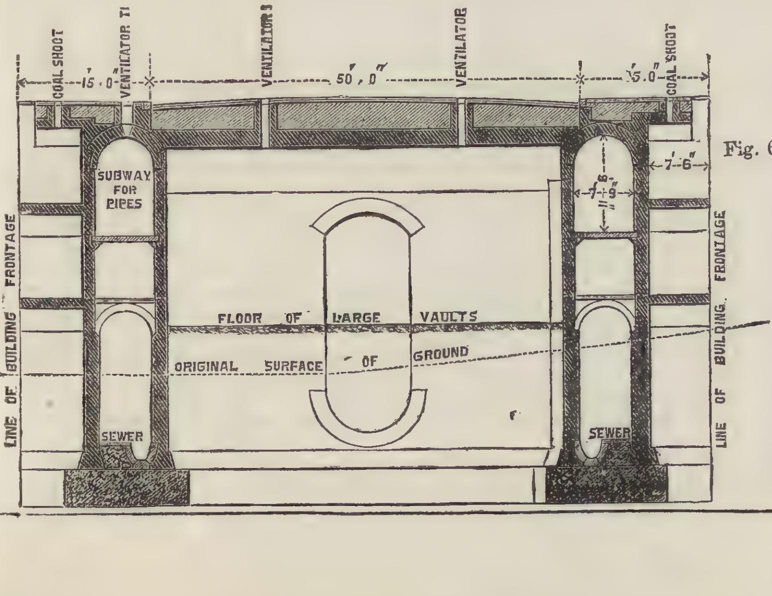
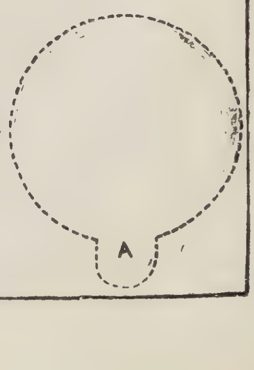


Fig. 64.

Fig. 55.



sewer—common as receiving the collected drainage of a street or district, and therefore common to all. The subject in itself is no new one, as it had received attention in early Roman times; and the remains of the Cloaca Maxima in Rome itself are still visible, a most excellent example of ancient masonry.

The question that first arises is as to the material to be employed. For small drains stone-ware pipes are now in universal use; but as these increase in size they increase in expense, and, except in special instances, are not to be obtained of a greater diameter than two feet, and the difficulty of manufacturing them to these dimensions renders brickwork the more economical material. There is also this point to be considered—that it is very desirable in extensive systems of sewerage that there should be a possibility of access from without throughout the sewer itself, so that in case of any obstruction, or failure in construction, it should be possible to get at it for removal or repair without opening the ground above or breaking up the course of the sewer itself. With a pipe-drain even of two feet diameter this is impossible, as the size must be sufficient to allow a man to pass, and we may take the minimum size as 3 feet 6 inches high by 2 feet 3 inches wide, the size now usually adopted by the Commissioners of Sewers of the City of London. We may take the opportunity here to thank Mr. Haywood, their engineer, for affording us this information of detail, and also for allowing us to publish the illustrations of the Holborn viaduct to which we shall presently refer. We may mention, as a matter of practice in the same district, that a 12-inch drain-pipe is now the largest size used; 15-inch pipes were used until quite lately, but their use has been discontinued.

We give in Fig. 53 a section of a form of sewer very generally used—showing the lower portion of the section as an "invert block"—specially burnt for the purpose in stone-ware, the upper portion being built of brickwork in cement. This section does not apply to any particular locality, but has been very generally used. The sketch shows the side entrance of a drain protected by a stone-ware trap to prevent flooding by storm-waters. The materials, of course, vary in different localities; we here only remark that they should be as much as possible non-absorbent. Soft, commonly called place bricks, should never be used, but the many recent improvements in the harder class of manufacture of late years place a large selection of materials at the command of the engineer. If possible, the internal surface of the sewer should be faced with glazed bricks, which are now readily obtainable in many parts of the country.

Fig. 54 represents a form of invert somewhat similar to the last, which was used in the sewers of the Holborn Valley district, to which we shall have occasion further to allude. A is the bottom surface of the sewer, C C is the stone-ware invert, B B B the brickwork; the whole laid upon the concrete foundation shown in the section.

A section of the form shown in Fig. 55 has been strongly advocated, and denominated self-flushing, as the lower channel, A, from its narrowness, is supposed to be more readily cleansed by the flow of water than the plain oval section, and it is probable that in dry districts which have not an abundant water-supply it may be adopted with advantage. Many other peculiarities of section are adopted by different engineers. We do not, however, further allude to these, but confine ourselves to authentic examples of sewers now extensively in use, and proceed to give a series of sections with which we have been furnished from the office of Mr. Bazalgette, the engineer to the Metropolitan Board, representing various sizes of sewers in daily course of construction in different parts of the London district; giving, also, calculated data as to size and quantity of material. These are shown in section in Figs. 56, 57, 58, 59, and 60; they run from No. 1, the largest, to No. 5, the smallest, and the quantities are expressed in decimals.

It may be as well to point out to any artisan who may be studying these papers, and who may require some instruction in the details of the mode of drawing the sections of these figures, that the intersection of the dotted lines meeting in an acute angle to the right or left of the diagram as the case may be, indicates the centre from which the arcs forming the sides of the sewer are to be struck. Further information will be found in "Technical Drawing" (page 15), where the entire operation of drawing the figure called an oval is fully and clearly explained.

The following gives the quantity of brickwork per foot-run in each of the sections of sewers, Nos. 1, 2, 3, 4, and 5, exhibited in Figs. 56, 57, 58, 59, and 60. The inverts of Nos. 1, 2, 3, 4, are in cement blocks; the sides in sound stocks in mortar in Old English bond. In No. 5 the bricks are all laid in cement, and the invert is a stoneware block. All of these sewers are bedded in concrete, as shown in the diagrams, up to the springing of the arch, unless the ground be sound and excavated to the exact form of the invert.

BRICKWORK PER FOOT-RUN FOR SEWERS NOS. 1, 2, 3, 4, 5.

		Feet cube.		*Feet reduced.*		*Rods reduced.*
No. 1.	In Cement	3·375		3·000		0·01103
	In Mortar	10·357	=	9·206	=	0·03385
	Total	13·732		12·206		0·04488
No. 2.	In Cement	3·375		3·000		0·01103
	In Mortar	8·862	=	7·877	=	0·02896
	Total	12·237		10·877		0·03999
No. 3.	In Cement	3·375		3·000		0·01103
	In Mortar	7·366	=	6·547	=	0·02407
	Total	10·741		9·547		0·03510
No. 4.	In Cement	3·375		3·000		0·01103
	In Mortar	5·870	=	5·218	=	0·01918
	Total	9·245		8·218		0·03021
No. 5.	All in Cement	5·93	=	5·27	=	0·01936

The particular size of sewer to be adopted in any particular locality must, of course, be determined by an infinite variety of circumstances, all of which are, however, a matter of calculation, and are readily ascertained by the experienced engineer.

We give in Fig. 61 (*a*, *b*, *c*), a section and plan of the side entrance to a sewer, published by the same authorities, showing how access may be obtained at any required points, and also in Fig. 62 (*a*, *b*, *c*) the details of a bell-mouth junction, which further elucidates the remarks we made in a previous paper on the junctions of drain-pipes, that these should never be made at right angles, but always in curves gradually coinciding with the sewer line in the direction of its current.

We may here point out that in the various sections of sewers shown concrete in certain proportions is provided. This is not in all cases necessary, and especially in the case of smaller sewers it may occasionally be dispensed with, when, however, the foundation is reliable—of good sound gravel or clay; but if the sewer has to pass through what is called "made ground"—*i.e.*, ground which has been disturbed and filled in again—a much larger concrete foundation should be provided than that shown in the sections; and we here remark that one of the most treacherous foundations is a piece of ground in which clay and gravel occur in alternate layers—a formation not uncommon in the neighbourhood of London, especially on the southern side. A bed of gravel, perhaps, on the side of a hill, intersected at intervals by narrow layers of clay, is apt to be very troublesome when opened for sewers or foundations, as the gravel seems to slide over the clay, and constant slipping is the consequence. In marshy land or soft sand it may also be desirable to extend the width of the concrete foundation considerably to prevent the risk of subsidence.

The question of sewer construction leads necessarily to that of the method of dealing with the sewage, and the details of flushing gates, penstocks, pumping stations, and many other similar requirements; but as these are subjects rather for the mechanical than the sanitary engineer, we shall not attempt to treat them in detail. We may mention, however, for the benefit of those of our readers who are in a position to avail themselves of the opportunity, that the whole of the contract drawings for the Metropolitan Main Drainage have been presented by Mr. Bazalgette to the library of the Institution of Civil Engineers, and may be there inspected by any one interested in the details of one of the greatest, if not the greatest, sanitary undertakings of modern times.

We conclude the present paper by a short notice of subways, in which may be contained, within one accessible passage, the gas mains, the telegraph wires, the water mains, and the sewers, accessible at all times for the purpose of inspection, alteration, or repair. We need hardly point out the great advantages of their adoption in all great metropolitan centres,

where the wealth and extent of the community render their introduction possible; but as the limits of our paper are nearly reached, we conclude it with a reference to two diagrams (Figs. 63, 64), showing two sections of portions of the Holborn Viaduct district, and clearly indicating the general arrangement. The larger section, that of the Holborn Viaduct (shown in Fig. 63), is no doubt exceptional from its extreme height; but we prefer illustrating, by this sketch in our present paper, a large undertaking recently carried out in all its details with thorough success, to laying before our readers drawings which, though perhaps more generally applicable to ordinary circumstances, have never been actually carried out in practice. It will be evident that, did our space allow, we might refer to many of our previous papers on gas, water supply, drainage, traps, and other points alluded to in the course of our present series; but the sections with which Mr. Haywood has favoured us are so clear in themselves, that if our previous papers have been read the drawings will easily explain themselves.

Our next paper will deal with the question of the ventilation of sewers, when we shall have again to acknowledge our obligation to the same authority.

GREAT MANUFACTURES OF LITTLE THINGS.—IX.

NAILS.

BY CHARLES HIBBS.

When Hutton, the historian of Birmingham, first approached the town he was afterwards to describe with so much humour and graphic power, he "was surprised at the prodigious number of blacksmiths' shops upon the road; and could not conceive how a country, though populous, could support so many people of the same occupation. In some of these shops," he goes on to say, "I observed one or more females wielding the hammer with all the grace of their sex. Struck with the novelty, I inquired, 'Whether the ladies in this country shod horses?' but was answered with a smile, 'They are nailers.'" At the time Hutton writes of, it is probable that the nail-making industry was carried on under conditions very similar to those which prevail in Belgium and some parts of France at this day, where a semi-agricultural population, occupying small holdings in the neighbourhood of the large towns, and deriving part of their subsistence from the soil, fill up their long hours of leisure by working at their own homes at some mechanical occupation, in which all the family can join. Cultivating a large patch of garden ground, or perhaps a small dairy farm, the Staffordshire nailer, and his wife, and his sons and daughters, used up all their spare moments in the nail-shop behind the house; and on the market day the good wife, clad probably in a man's flannel jacket over her looped-up gown, would trudge beside the donkey-cart to the nearest market town, perhaps eight or ten miles distant, and there dispose of her butter, and take the week's work of the family to the nail warehouse, where it was weighed in and paid for, and a fresh supply of nail rods given out for the next week. They were a hardy and laborious people, much given, it must be owned, to deep potations of ale, and lamentably ignorant; the children being put to the nail-block as soon as they were able to grasp a hammer, and even before that time they were made useful in blowing the bellows. In the course of time, as the district became honeycombed with coal-mines, the market gardens and the dairy farms were swept away, but the nail industry remained, and became the sole support of many a family. At one period it was computed that 60,000 persons were earning their subsistence at nail-making, and, as times were, their wages were fairly good. Large contracts for tea-chest nails came annually from the East India Dock Company; the Admiralty took between 600 and 700 tons a year; a large trade was done with Canada and the United States; and with the home demand these were generally sufficient to keep the nailer in constant work the whole year round. He had his seasons of holiday, during which it would have been sacrilege to strike a blow. The most notable of these was the wake, when, like the Dane at Yule, he

"gorged upon the half-dressed steer,
Caroused in seas of sable beer;"

and made merry, in his uncouth way, with bull-baiting, and such barbarous sports, the whole week through, to pinch for it a fortnight after. When work was going on briskly there was many a less cheerful scene than that presented by the nail district, comprising Dudley, Darlaston, West Bromwich, Oldbury, Rowley, Tipton, Bilston, and Wednesbury on the one side, and Stourbridge, with the adjacent district, known by the euphonious title of the Lye-waste, on the other. On a murk winter's night, when the sky was all aglow with the fires from the blast-furnaces, and the lurid flame, invisible by day, of some ignited pit mound, the music of the nailing hammers might be heard all the country round. From the little huts or sheds, dotted here and there upon the broken landscape with an utter absence of order or convenience, as though the mighty geological operations underneath had shaken them into the most unlikely places, the gleam of the hearth-fires would shine from the open shutters, and the merry songs of the workers, male and female, sung at the very topmost pitch of their voices, might be heard a mile away. Up to ten or eleven o'clock at night would these sounds continue—no uncommon circumstance in a district where labour never seems to rest, but where the roaring furnaces and the great rolling wheels go on unceasingly, day and night. Through the open loop-hole the whole art and mystery of nail-making could be witnessed by any passer-by. The nailer would have the ends of three or four rods in the fire, and taking out the one which had been in longest, after a pull or two at the bellows to bring it to a welding heat, he would taper down the point upon his anvil, at the same time making a shoulder for the head. He would then hold it over a chisel or cutting-punch, stuck upright at the side of his anvil, and, giving it one tap with his hammer, cut it halfway through; an iron stop in front of the punch giving him the exact gauge for the length. He would then turn down the point of the half-severed nail into a steel instrument called a *bore* (the top of which formed a mould for the head), and twist it off, and then, with a few smart blows, he would beat it down until the head was spread out sufficiently, and assumed the required shape, the nail just turning from red to black as he gave it the finishing tap. As his rods got too short, he would weld or "shut" two of them together, and put a new rod in the fire, and so on, with the regularity of clock-work, probably in a thousand nails not once varying the number of blows upon each. A great feat in the trade was making nails so minute as to be scarcely perceptible with the naked eye. A quantity were shown at the Exhibition of 1851, which, being put upon clean white paper, looked like so many grains of dust; but which, when examined through a microscope, appeared well-formed and perfect nails, each with the marks of seven distinct blows upon the head. A veteran nailer was attached to his hammer as a cricketer to a favourite bat: its haft was made to suit him, and he could work with no other; but with it he could perform wonders. Hutton, the historian before mentioned, said that the hammermen of Staffordshire were so skilful that he verily believed they could forge images upon the anvil.

Nail rods were produced by rolling iron, in the first place, into plates of the proper thickness, and afterwards passing these under *slitting* rollers, which split them into long square rods. Odd pieces of this material may be seen in the nail district serving various purposes, not the least frequent of which is that of tying the parts of a pig-stye together. There are various qualities and sizes, to suit the different varieties of nails, the best being used for making horse-nails, which require to be exceedingly tough and fibrous to admit of being driven into the hoof without breaking. Old horse-nails were at one time used extensively in the manufacture of the best gun-barrels, partly because the iron of which they were composed was of known good quality, and partly, it was supposed, from some additional property of toughness they acquired in the horse's hoof. It is probable, however, that the only advantage so derived was a guarantee that they were real horse-nails, and that they had stood the test of use—a guarantee which modern fraudful ingenuity has rendered valueless, for sham horse-nails, not to be distinguished from real, have been thrown in large quantities upon the market. Wheelwrights require good nails; so do hurdle-makers. There are as many as 3,000 different kinds of nails distinguishable by name—such as clasp, clout, and counter-clout; rose, dog, brads, tacks, etc. "A ten-pound

rose" would signify a rose-nail, of which a thousand would weigh ten pounds. Each locality produces its own special kinds; and a factor who would deal in all descriptions of nails must draw his supplies from widely separated places.

The first account of nail-making machinery occurs in the Patent Records of 1790, when one John Clifford obtained a patent for rolling them. He had a pair of rolls, cut all round with a series of nail moulds or matrices, heads and tails together, one-half of the impression in each roll, so that the rod came out converted into a string of nails, which required to be separated by cutting nippers. This plan was, of course, only available for the larger sizes, though he described it in his specification as "an entire new mode of manufacturing nails of every kind by machinery, never before made use of for that purpose." The same inventor afterwards took out a patent for punching nails from plates of iron, which was rolled taper for the purpose, having a thick side and a thin one. A punch and die, having the same taper, cut out spikes from these plates, and the heads were afterwards "upset," as the term goes, by another operation. This was coming nearer to the present method.

Guppy's patent, in 1796, was for cutting nails from plates by means of passing them under a roller having two cutters fixed at two opposite parts of its circumference. Underneath the roller was a movable piece called a vibrator, fitted with a die, which came in its motion under the cutters, and enabled them to cut off a piece the shape of a long thin wedge from the plate. This was then conveyed, by what the specification describes as "a chain calculated for the purpose," to a vice, which tightened up as it received it, held it while three taps of a hammer were given to it to upset the head, and afterwards opened out and let it fall; the whole being effected by one revolution of a wheel. This must have been a somewhat ingenious machine.

Visitors to the Workmen's International Exhibition of 1870 will have seen, among the machinery in motion, the modern process of nail-cutting. A girl sits in front of a press worked by steam, holding a strip of iron in a pair of long pliers, the handles of which are tightened up to retain it firmly; and turning it over rapidly at each stroke, a continuous stream of well-shaped nails falls from the machine, the head of one being formed from the point of the next, and *vice versâ*. The formation of the die and punch is somewhat peculiar. In the bed of the press is cut a square oblong hole, in which a punch of the same shape works, filling it exactly, and forming a solid block of steel, rising and falling with the motion of the press. The punch never rises entirely out of the hole, but on its under side is cut a step, the shape of the nail to be produced, and the girl inserts the strip of sheet-iron under this step as it clears itself from the hole, pressing the end of the strip against the solid part, and the sharp edges of the step cut off the nail. This arrangement causes the machine to work rigidly, and avoids bending the nail. Those small tacks called sparrowbills, which are much used by shoemakers, and have no projecting head, are most easily cut by this process; while sprigs, which have a head projecting to one side, are also formed with great neatness and regularity. On putting two of these together, head to point, it will be found that they fit into each other with extreme nicety. More complex machines there are, one of which we shall presently attempt to describe, which avoid this alternate process by a feeding apparatus which vibrates from side to side; while others, which make nails of different shape, have a supplementary contrivance for forming the head. There are few kinds of nails which cannot now be formed by machinery, and the trade in them is enormous, though probably not nearly so many hands are employed as in the best days of the hand-made nail-trade.

The revolution in the nail manufacture was completed by the introduction of an elaborate automaton machine, patented by Messrs. Ledsam and Jones, in 1827. A massive rigid framework, in shape like the skeleton of an oblong table, sustained, in the first place, a shaft working underneath, with a crank in its centre, which gave motion to the upper machinery, and was itself set in motion by a band-pulley at the end of the frame. On the top of the table were two massive slides, working in grooves, moving horizontally opposite ways from the centre. Motion was communicated to them from the crank by means of a rod and a toggle or knee-joint, which it is necessary to pause and describe. It consisted of two separate arms or levers, hinged together at one end, and the other ends hinged to the two sliders. When the crank-rod was connected at one end to the crank itself, and at the other end to the central hinge of this knee-joint, of course every revolution of the crank would cause the knee alternately to bend and straighten, and by consequence cause the sliders to move backwards and forwards. When it was at the upper part of its revolution the knee would be bent upwards, and when it was at the lower part it would be bent downwards; while at the middle part the knee would be perfectly straight. The nature of the motion gave almost irresistible impetus to the sliders, especially at the moment when the knee-joint was assuming the straight position. The reader has seen the very common children's toy, a box of wooden soldiers, with a slight jointed framework on which they can be stuck, and which elongates and contracts by moving the ends which are held in the fingers; this is simply a combination of toggle-joints. The sliders were fitted with cutters of rhomboidal shape, which could be fixed and taken out at pleasure, and were held firmly in their position by screws. As the sliders moved in their grooves, the sharp front edges of the cutters passed immediately under the corresponding edges of two other cutters, fixed rigidly in a position overhanging the frame. So far the cutting part of the machinery; what remained constituted the feeding apparatus. Hung to the frame we have described was a second oscillating frame, enclosing and overhanging it, which derived its motion from an excentric fixed on the crank-shaft. Through grooves in the upper part of this frame the strips of iron to be cut descended gradually to the level of the cutters, being held upright by means of rods depending from a beam overhead. A holder received the upper end of the strip, and this holder could be so fixed upon the depending rod as to slide down it by its own gravity, being weighted sufficiently for that purpose, and to allow of the strip of iron falling at a sufficient rate of speed as it was cut away. The business of the oscillating frame was to present the strip to the cutters at such an angle as to allow of a perfect nail being cut off, and the only attention which the machine required was the putting in of fresh strips, as the old ones were cut to the stump. Not the least ingenious part of the machine was the excentric, which could be adjusted to suit every size of nail by a screw, the head of which could be reached with a spanner.

Nails which required to be headed after they were cut, were subject to a defect arising from the extreme squeeze which was required to be given to them to hold them sufficiently tight for the head to be formed when cold. To obviate this a manufacturer, named Kingham, patented an improved machine in 1868, the object of which is thus set forth in his specification:—"The ordinary machine-cut nail is so griped while being headed that it is pressed out of shape, being of different form and often smaller immediately under the head than at a short distance below it; while the nail made by my improved machine is griped by dies so made and operated that the symmetry of the nail is preserved, or, in fact, improved; the shank being pyramidal, and thus suited for boat-building and other purposes."

The history of the hand-made nail trade since the introduction of machinery is a sad record of strife and disaster; abject poverty on the part of the workers, and often cruel oppression on the part of the employers. The numbers engaged have dwindled from 60,000 to less than 20,000, and the wages of those left in almost the same proportion. He is a clever nailer who can earn 12s. a week; and the labour of the whole family scarcely suffices to keep body and soul together. The Factory Act is inoperative in these districts, the work being done still at the nailers' own homes, which makes legal inspection and supervision practically impossible, and the poor untaught children are put to work at the very earliest age, for the sake of the few pence they are able to earn, thus bringing up another generation to cling hopelessly to a declining industry. Wages are largely paid in truck, in defiance of the law, and the number of respectable money-paying firms is constantly on the decline. The poor workman is often glad to exchange his morning's make of nails for a meal at the truck shop, or he is compelled to accept a little credit, from which moment the truck-master has him under his thumb. The cash-paying masters have often tried to put an end to the infamous truck system, but in vain; and the competition of the truck masters in the market compels them unwillingly to lower the wages of their work-people. To their honour be it said, they have not done so

without endeavouring on several occasions to make a public stand against it. At a meeting of nail-masters held in 1842, the following resolution was passed :—

"That, although this meeting is informed that some masters have been reducing wages for some time past, it is the opinion of this meeting that wages, as already fixed by the masters, are low enough, and they entreat those masters to give the full amount of wages, thereby preventing that distress which must otherwise follow such practices."

No trade has suffered so much from strikes; and a memorable one which took place shortly after the meeting referred to, led to the military being called out and the Riot Act read. Seldom has a strike resulted in anything but a further reduction; and the prospects of the future trade may be estimated, when it is stated that some descriptions of machine-made nails can be sold for one-fifth of the price of those that are hand-made, although the price of these last is not one-half of what it was.

Still it is supposed that there will always be a demand for some kinds of hand-made nails, and there are some which cannot be produced of sufficient quality in any other way. Among these are horse-nails, and in this branch wages were even greatly advanced during the period we speak of. It has been found impossible to get the requisite amount of toughness otherwise than by working the metal under the hammer, and this being the case, workmen are able to command a fair remuneration for their labour. Still the trade gives employment to comparatively few.

Copper nails, or nails cast from a mixture of copper with some cheaper alloy, are much used in ship-building, and especially for fastening on the sheathing to the bottoms of vessels. It was found that when the heads were left rough the ship's bottom fouled much faster than usual, and that a barnacle was sticking to every nail. The heads of these nails have, therefore, to be turned and smoothed in a lathe.

CAPITAL AND LABOUR.—II.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

POSITION OF THE QUESTION IN ENGLAND (*continued*).

It is very unfortunate that the hopes to which we drew attention at the close of our first paper on this important subject have been raised, for assuredly they will not and they cannot be gratified. A government is never, except for very short periods, in advance of the opinions entertained by those whose affairs it administers. No reform in the ways or habits of any society can ever be achieved except by those powers which lie within society itself, and which may be aroused or strengthened by the presence of those occasions on which they can be exercised, and by the heads and hands of those who understand and wield them.

In England the case has been very different. Here the habit of spontaneous agency, of self-government, of association, of combined action is so strong and so familiar, that no sensible person in this country expects that a government should do more than take away hindrances to such combination and association—should attempt anything beyond giving as much liberty as is consistent with order and quiet. English people, therefore, rarely expect that the government under which they live should take in hand the settling of their condition by finding employment for unoccupied hands, still less that it should re-distribute the wealth which the various individuals of which society is composed have collected. In other words, they expect, provided only that action is free and law is fair, that the condition of each person, and his share in the general product of labour, will be settled by competition, or arrangement, or contract.

Unfortunately, law has not, in times past at least, been at all fair. For nearly five hundred years the English law, though it put no hindrance in the way of employers, so as to prevent them from making the best bargains they could, put very serious hindrances in the way of labourers. The beginning of this system was the occurrence of a sudden scarcity of labour, and a consequent rise in its price. In order if possible to check the rise, laws were enacted forbidding employers to give, and labourers to receive, more than the wages which prevailed before the scarcity occurred. In time a different expedient was adopted in order to attain the same end. The magistrates were empowered to fix the rates of wages at their quarter-sessions. In other words, the employers of labour were allowed to determine by law what they might choose to pay their workmen, and the workmen were obliged to be content with the allowance which was made them. At the same time any association of workmen, which had for its object the discovery and employment of means by which the rate of wages might be heightened, was *strictly prohibited* and *severely punished*.

It is one of the consequences of an unwise or unfair law—those two words being in legislation almost synonymous—that the evil it does lasts long after its abrogation. The fact that this legislation was directed against the workmen, and that it stood in the way of attempts on their part to better their condition, left permanent feelings of suspicion and distrust in the minds of the labourers—of suspicion and alarm in the minds of the employers. There is no country in the world which has witnessed so many disputes and bickerings as England has in its various industries. Sometimes they took the form of riots and machine-burning, sometimes of strikes and lock-outs. On the whole, perhaps, the rate of wages earned by skilled artisans is greater, and the hours of labour are shorter, than in any European country, not indeed that the former are too great, or the latter too light. But there is no other European country in which there have been so many bitter and angry disputes between employer and workman.

Another reason why the relations of labour and capital (using the words in their popular meaning as denoting the bargains between employer and workman) have occupied so much space in social and economical philosophy, is the fact that the line between employer and workman is drawn with far greater strictness in England than it is elsewhere. In one kind of industry the line is seldom overpassed by the workman. It is very rarely the case that an agricultural labourer succeeds in becoming a tenant-farmer. In other industries it constantly happens that the workman tries to become an employer, or at least to work on his own account. This is particularly the case in those callings which are very widely distributed, and for which there is consequently a very general demand, such as the building trades. But in several callings it is seldom the case that the workman in England rises to be an employer. He is apt to remain permanently in his condition.

The case is very different in other countries. In Germany, for example, the workman on his own account is the rule, the capitalist employer and the hired labourer the exception. England is the country of large capitals, custom, and much more law, assisting in the aggregation of wealth, and discouraging its distribution. Now whatever the word capital may mean, it always means wealth employed actively for the purpose of obtaining income or profit, as the case may be; and therefore, where large capitals exist, there always will be a tendency towards stereotyping the two classes of employers and workmen. Of course if the habit of association were to spring up among workmen, the capitals which many men could collect, as has been proved in certain co-operative undertakings, may become far in excess of the largest capital possessed by private proprietors.

There is one advantage, however, which the English law has given the labourer at all times. It has considered his wages as a secured debt. In other words, if the employer becomes bankrupt or insolvent, his labourers have a claim to be paid in full, before any part of his effects can be distributed among his other creditors. It is probable that the origin of this custom is to be found in those times in which the payment of labour was generally made by granting the occupation of land, or *vice versâ*, where the occupier of land paid labour in liquidation of his rent. But whether this be the cause of the custom, or it be assigned to some feeling of humanity, the practice has a defence, in the fact that the labourer, in so far as he advances his labour to his employer—as he generally does—has disposed of his whole property or capital to one man, and therefore would be put in a disadvantageous position by the side of any other creditor, who may be supposed to have lent only a portion, and a small portion, of his capital to his debtor.

There are, then, several reasons which may account for the prominence which the relations of labour and capital possess in the theory of English social life. Some of these reasons are derived from the freedom which characterises contracts and associations in this country, some are the consequences of our

law, some are derived from the peculiarities of our trade and manufactures.

PROFITS OF CAPITAL.

My reader will see that in the foregoing remarks I have used the words capital and capitalist to represent the resources and the function of the employer. But I have done so under protest. The workman, in so far as he possesses the strength and the skill necessary for the work which he undertakes, and in so far as he lends his labour to the employer, before he receives his wages, is just as effectually a capitalist as the employer is who hires him. Familiar usage, and the necessity of making a distinction between the two principal agents in most productive actions, render it convenient to speak of the employer as a capitalist, and the artisan as the workman, though both possess capital, and both do work.

The remuneration which the work of the capitalist obtains is called profit. It must not be imagined, however, that all that which he is enabled to appropriate as his share is paid him for the work which he does. He may employ the property of others, and pay interest for the loan. Now, interest is the reward which a man obtains for allowing another to use his property. In so far as the employer has property of his own, so he will expect and get interest for his property, as certainly as though he borrowed the property of other people; in just the same way as a man who cultivates his own land, receives, so to speak, rent from himself. The amount of interest which a person can get for the use of his property depends entirely on the quantity of property which can be lent, and the uses which borrowers can put such property to. If the property be scanty, and the desire to use it keen, the rate of interest is high. If, on the other hand, the property is abundant, and the wish to use it slight, the rate will be low. In neither case is it necessary that the profit of the employer should follow the rise and fall in the rate of interest. At the present moment, the rate of profit in many callings is very high, but the rate of interest is exceptionally low.

Again, part of the remuneration which the capitalist receives is security against risk. Business is ordinarily conducted in such a manner as that no loss occurs in the great majority of transactions; but no business is free from risks. Apart from the chance that a purchaser may be insolvent, and therefore be unable to pay his debts, there are risks that the manufacturer may have produced more than the market requires, or than the public fancies, or have offered something which nobody cares to purchase, or have made a loss in the purchase of his materials, or have made some other miscalculation. These chances are so numerous and so serious that it is not too much to say, that they who prosper in life generally do so, because they have contrived either by skill or good fortune to escape some of these losses which others, not so intelligent nor so fortunate, have suffered. In such a case, the former gets an advantage from the losses of the latter. Business is calculated on the average of profit and loss, and the man who individually incurs the least loss, gets most profit.

Take out of the quantity which the employer of labour appropriates, that which he receives as interest on his property, and that which he lays by as a security against risk, and the residue is gained by him, because he gives pains and trouble, or, in other words, labour, to the calling in which he is engaged. It will be seen, therefore, that there is no economical difference between the true profits of the employer and the wages of the workman. Both are payments for work done, and both are made because work is done. Both are wages; and sometimes persons have spoken of the "wages of superintendence," as part of the profits of the employer. In reality, if the exposition given above is intelligible, profits are wages in disguise.

The distinction and similarity between profits and wages are no mere verbal limitations. It is wholly essential to a right understanding of the relations which subsist between labour and capital, that the resemblance between profits and wages should be recognised, for by this fact we are able to discover what there is at the bottom of all those struggles between labourer and capitalist, which are so constantly observed and commented on, but so little understood. In brief, these struggles generally consist in an attempt on the part of the employer to increase his rate of wages, and a similar endeavour on the part of the workman to increase his.

It is commonly said that profits tend to an equality. This statement is very imperfectly true. Interest not only tends to an equality, but, if the securities are equally good, actually makes an equality. Risks are not an equality, but an average. It is only because that part of what is called profits, which is really interest, and that part which is half insurance appear to be, and to a great extent are, equal in most callings, that this error of the tendency of profits to an equality has arisen. Wages do not tend to an equality, even when they are the wages of workmen; for they vary not only by reason of time and place, but much more by the comparative skill of the workman. Still more, however, do the wages of employers vary, because the skill of different employers varies exceedingly. One employer makes a fortune, another hardly gets a living. It is absurd to say that their profits are equal, or even tend to equality.

There are two ways in which greater profit, in the sense which I have assigned to this word, is made. One of them is by lessening cost; the other is by multiplying transactions. Different kinds of business give very different opportunities for these two sources of increased profit. It will be clear to every one how powerfully manufacturing profit is affected by the first of these processes. A piece of woollen cloth is woven at the present day for a tenth of the cost which was incurred a century ago. By a discovery that woollen rags could be used over again, the saving of cost in the manufacture is assisted by a saving of cost in the material. Now, as long as any lessening in the cost is the property of one man, it becomes his profit, and his only. As soon as it belongs to all other manufacturers, either the public will get the advantage, in the lowering of prices, or the labourer will share the boon in the increase of his wages. It will be plain, however, that the intelligence which lessens cost is a kind of labour, and a very important kind too.

It will be easy to illustrate the other manner in which the individual increases his profit. The labour of a stockbroker consists in purchasing securities on behalf of his customers, he receiving a fee in the form of a per-centage on the purchase or sale of the security. The business of the broker is to get as many of these commissions as he can; there is no limit to his power of doing such business. If a single broker kept clerks enough, he could buy and sell every pound's worth of the stocks and shares which change hands in the market. His function is to be known and to be trusted.

This leads me to point out what is meant by good-will. There are some kinds of business in which the connection between the trader or workman and his customer is so valuable, that if it be judiciously transferred, it will sell at a very great price. Instances of such a kind are the business of a banker in good repute, or an attorney who has what is called a good family connection. In both these cases considerable advantage is gained out of ordinary routine transactions, over which a general supervision on the part of the manager is all that is necessary. Of course the basis of this connection is a reputation for integrity and good faith.

The profits of trader and manufacturer are always highest in those countries which are rapidly growing in wealth. But they are highest in such countries, because the wages of all labour are high, provided of course that the labour is useful, and therefore in demand. Now this result occurs in the most marked manner when the business of such countries is brisk, and the resources are great. In no countries are profits higher than in such newly-settled regions as possess abundant land, the produce of which can be easily brought into the markets of those countries where population is abundant, and land fully occupied. Similarly, in a country like our own, where there are extraordinary opportunities for obtaining that increase of profit which comes from very numerous transactions on commission, large fortunes are made from that kind of business in which such commissions can be indefinitely extended.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVII.

BY E. WYNDHAM TARN, M.A.

BRINGING INTO BILL.

We now come to the last operation to be performed by the measuring surveyor, and the one for which all the previous

operations are only preparations; this is called bringing all the measurements into bill, and is performed by taking the several items *seriatim* from the abstract, and entering them in proper order on ruled bill-paper, so that the prices per yard, foot, rod, or each, can be attached to them, and the work priced out.

The following order should generally be observed in bringing into bill. Cubed articles to be placed first in each trade, then the superficials, then the runs, and lastly the numbers. It is also usual to begin with low-priced articles, and enter them in increasing order. These rules will be best explained by presenting our readers with a detailed bill of all the items contained in the abstracts previously given under the several trades.

BILL OF QUANTITIES.

EXCAVATOR.

YDS.	FT.	
74	5	Cube, digging in clay, 1 throw, and carting 1 mile
$28\frac{1}{2}$	0	„ ditto, ditto, 2 throws, part filled in and rammed, part wheeled two runs
$77\frac{1}{4}$	0	Ditto, ditto, in gravel, 2 throws, filling in and ramming
12	8	Supl., clay puddling to vaults
$180\frac{1}{2}$	0	„ levelling earth, average depth 12 in.
$41\frac{1}{4}$	0	Run, planking and strutting to trenches, 7 ft. 6 in. deep, 2 ft. 3 in. wide

WELL-SINKER.

FT.	
25	Run, digging and steining (dry) to well, 3 ft. diameter in the clear, gravel soil
10	„ ditto, ditto, in mortar to cesspool, 6 ft. diameter in the clear, clay soil
40	„ boring through sandstone rock, with a 3-in. auger

Carried to summary . . £

BRICKLAYER.

YDS.		
$15\frac{3}{4}$		Cube, concrete in foundations, composed of 1 part lime to 6 parts ballast
$49\frac{1}{2}$		Supl., 6 in. concrete floor composed as above
$2\frac{1}{2}$		„ ditto, 1 part Portland cement, and 8 parts ballast
$21\frac{1}{4}$		„ ditto
		„ ditto in 9 in. walls, with use of apparatus
FT.		
23		Cube, stock brickwork in mortar to copper
RODS.	FT.	
12	160	Supl., reduced stock brickwork in mortar
	195	„ ditto, fence walls
YDS.		
34		„ brick nogging to partitions
$89\frac{3}{4}$		„ Malm facing
112		„ tuck pointing
231		„ flat joint pointing
$99\frac{1}{2}$		„ $\frac{1}{2}$-in. tile paving in cement
$7\frac{1}{2}$		„ 1 brick vaulting in mortar
4		„ brick on edge, paving in sand and grouted
FT.	IN.	
86	1	„ Asphalte
76	8	„ Malm cutter arch
20	5	„ cutting to splay
18	0	„ $\frac{1}{2}$ brick trimmer arch
31	0	Run, chamfer to brickwork
32	0	„ double tile creasing
65	0	„ extra to brick on edge coping in cement
22	6	„ cutting chase for rain-water pipe
60	0	„ 6 in. glazed ware socket-pipe drain, and jointing in cement
YDS.		
376		„ iron hooping as bond, $1\frac{1}{2}'' \times \frac{1}{16}''$
		Number—
		6 flues cored
		6 chimney pots, and setting in cement
		1 range setting
		5 stoves ditto
		12 sash-frames and door-cases, bedded and pointed
		8 air-bricks
		3 6-in. junctions to drains
		2 ditto bends ditto
		1 ditto syphon-trap ditto

Carried to summary . . £

TECHNICAL DRAWING.—LXXIV.

DRAWING FOR BRICKLAYERS (*continued*).

We purpose in the present lesson giving some further illustrations of drawing.

Fig. 596 is a section of a drain of the oval form.

Before drawing this, it will be well that the student should be reminded that the difference between an ellipse and an oval is, that the former is equally curved at both ends, whilst the latter has the one end larger than the other, similar, in fact, to the form of an egg, and hence its name (from *ovum*, an egg). The following figure (Fig. 597) from "Practical Geometry applied to Linear Drawing" is here repeated in order to save trouble of reference:—

To construct an oval, the width A B being given. Bisect A B by the line C D, cutting A B in E. From E, with the radius E A, draw a circle cutting C D in F. From A and B draw lines through F, and produce them indefinitely. From A and B, with radius A B, draw arcs cutting the last two lines in G and H. From F, with radius F G, describe the arc G H, to meet the arcs A G and B H, which will complete the oval.

Now in Fig. 597 it will be observed that only the width is given, whilst the depth at D is found by the radius of the arc drawn from F.

In Fig. 596, however, the height of the drain, as well as the width, is given.

In this drain the span is 3 feet and the height 4 feet 6

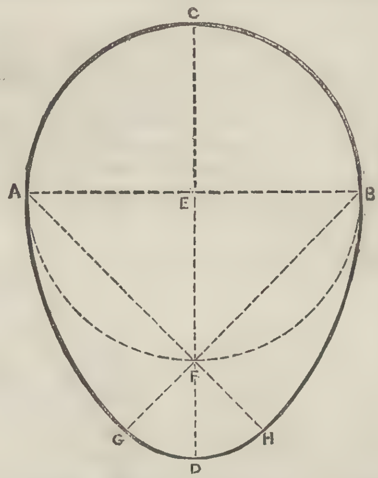


Fig. 597.

inches. The upper arch is a semicircle of 18 inches radius, and the lower curve is the third portion of a circle of $10\frac{3}{4}$ inches radius, the centre of which is of course set off on the centre line at the distance of the radius from the bottom. These two curves are united by arcs struck with a radius of 4 feet $10\frac{3}{8}$ inches, the centre being on the springing line produced.

The upper arch in this example is formed of two $4\frac{1}{2}$-inch rings, with occasional whole bricks laid as headers, or bricks of a wedge-like form purposely moulded.

The sides of the drain are worked as rough arches in whole and half brick, the half brick being of course half in appearance only, the whole brick lying in the direction of the drain.

The lower arch is formed of bricks purposely moulded to the form, by which means the closest possible joint is obtained in that part of the drain through which the sewage is passing, and which should therefore be rendered absolutely impervious to water.

In relation to bricks purposely moulded as superseding rubbed bricks, we extract the following passage from Mr. Gilbert Redgrave's official report on this section of manufactures in the International Exhibition of 1871:—

"Much as we admire it, we cannot help considering rubbed brickwork to be false in principle. There is no doubt that rubbing has been resorted to in some of the most beautiful work which we possess, and we must admit the new buildings at South Kensington are most excellent examples of the judicious employment of red bricks. But we are convinced that as bricks are necessarily moulded in the process of manufacture, it is a mistake to tamper

with and shape them after they have left the kiln. It is really doing the work twice over to cut them into fantastic shapes when they might have received these forms in a quarter of the time while the clay was in a plastic state."

The following example (Fig. 598) is a section of the principal drain at King's Mews Barracks, near Charing Cross.

It is 2 feet 6 inches wide by 4 feet 9 inches high in the clear. The sides are straight for nearly three feet in height, and are one and a-half brick thick. The arch at top is a segment approaching to a semicircle, and at bottom a flat segment-arch is used. These arches are one brick thick. The foundation is level, and small buttresses (not shown in the figure) are added at intervals. In concluding this section it may be observed that all drains should be well considered before a building is commenced, and they should be amongst the first things executed. The ground for the foundation should be levelled according to the proper slope, and carefully examined before the brickwork is begun. A drain should never be made to turn abruptly in any part of its course when it is possible to avoid it, and for the same reason it is best that the branch drains should not enter the principal drains at right angles, but should, when possible, be slanted a little, so as to favour the direction in which the water is to flow. It is, of course, proper to make the branch drains somewhat higher than the principal drains, to prevent the greater body of water in the latter from flowing up into the former and choking them.

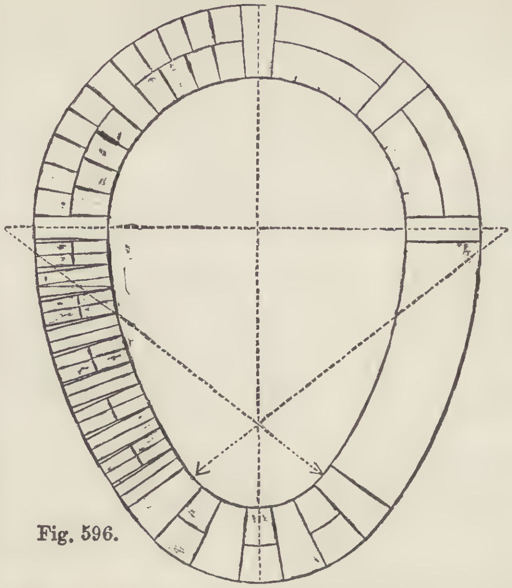


Fig. 596.

PLAN DRAWING.

The various kinds of drawings used in the erection of buildings are by most people classed under one general name, "plans."

This massing together of all the drawings is, however, wrong technically. The drawings consist of plans, elevations, sections, and working drawings. These have been already fully explained in "Building Construction," and need, therefore, be only briefly alluded to in this place. The plans, it will be remembered, are classed as—

1. Block plans: showing the mere outlines of the buildings, and their position in relation to the surrounding objects.

2. Excavation plans: showing the shape of the trenches to be dug for the foundations, cellars, underground kitchens, etc.

3. Basement plans: showing the foundations and works up to the level of the ground, or, as it is called, the ground line.

4. Floor plans: including (1) the ground-floor plan; (2) the chamber plans, showing the disposition of the different rooms, which are not always arranged as on the ground floor; but, of course, the main walls necessarily cause the general apportionment to be the same; other divisions are accomplished by means of partitions; and (3) the attic plan, showing how the garrets or attics are arranged.

5. Roof plans: showing the manner in which the roofs are disposed, so as to secure the fall required, that rain may at once pass off by the gutters and spouts.

Plans resemble the appearance of any object viewed from a height above it. They represent not only the piece of ground occupied, but the space it overhangs as well. This has been fully demonstrated in "Projection," in which the principle of projecting elevations from the plans has been fully worked out.

Plans, therefore, do not convey any notion as to the *appearance* of a building, but as to its *reality*. They do not show how the building looks, but how its different apartments are arranged. Nor are plans associated in the mind with what may have been seen; for, of course, a true view of a roof, such as would be given in a roof plan, could only be obtained from a point above it, looking immediately downwards.

Ground plans or foundation plans of buildings or other works do not give any just notion of the appearance of the object represented, because when a building is finished, it is impossible from any point of view whatever to see the various walls and foundations in the manner in which they must be represented in the ground plan, the whole of these parts being hidden by the very building reared upon them.

In fact, the ground plan of any finished building is, properly speaking, a section through the various walls; the only difference between it and a common section consisting in this: that the common section is taken vertically, whereas the actual section of a building which is exhibited in any ground plan of it is supposed to be taken *horizontally*. Thus, if the student can imagine a house cut through horizontally, immediately on the line of the first floor—that is, on the level of the top of the first flight of stairs—and the whole part above this cut including the floor to be removed, a drawing made of the edges of the walls, of the floors, and stairs they include, would be the plan of the ground floor.

Since, then, the elevations must be entirely dependent on the plans, the utmost care must be exercised by the student, not only in the design, but in copying such sets of drawings, since they must correspond with each other with the utmost degree of accuracy.

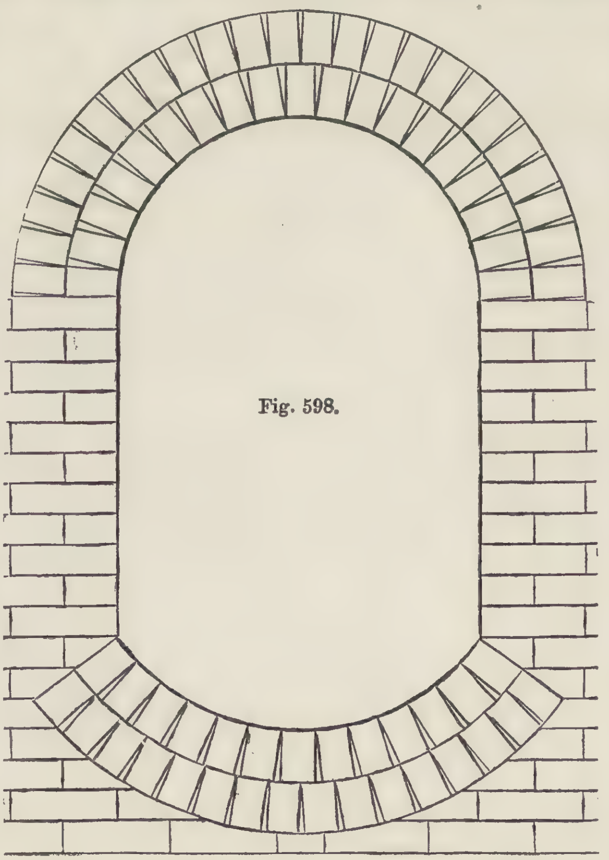


Fig. 598.

MINING AND QUARRYING.—XXVI.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

LEAD FUME—COMPOSITION—VALUE OF FUME—MODE OF COLLECTION—REDUCTION—SOFTENING OF LEAD—TREATMENT OF DROSS—NAPLES YELLOW—CHARACTERISTICS OF PURE LEAD.

In the last article the objectionable character of the waste gases from the lead-smelting works was briefly referred to. Those who have passed through the Swansea valley will have been impressed with the utter absence of any vegetation, which is due to the sulphurous acid evolved in the course of copper-smelting; but the destruction of all plant life is the only serious objection to the presence of copper works. It is not so with those where lead ores are treated: were they to be as near Swansea as the copper works are, and were the same low chimneys to be used, the town would be absolutely uninhabitable. The whole of the population would soon present symptoms of lead-poisoning.

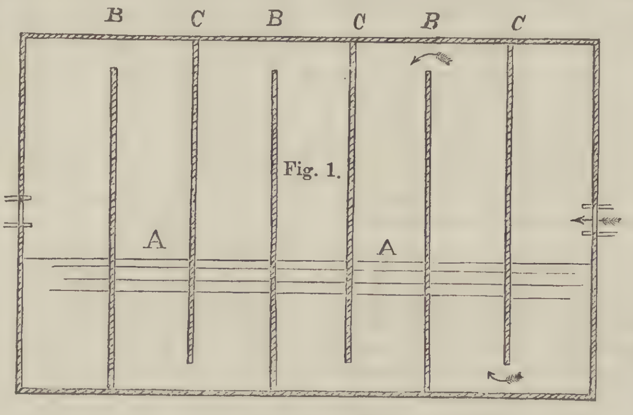


Fig. 1.

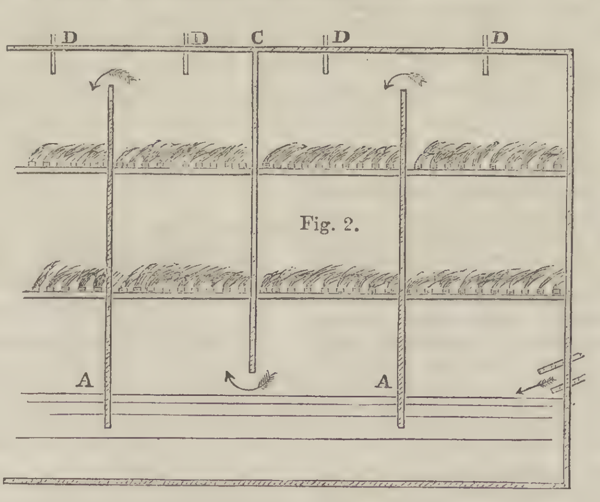


Fig. 2.

It is the lead fume, as it is technically called, which must be prevented from passing into the atmosphere; the sulphurous acid gives no trouble to the lead-smelter. The lead fume, moreover, is of very considerable value, too great to allow of its being lost. In composition it varies somewhat, but the principal ingredient is always sulphate of lead, the proportion of which will range from 65 to 85 per cent. There is usually some oxide and sulphide of lead as well, the rest consisting of silica, lime, alumina, etc. As it comes away from the furnace it most probably consists of sulphide and oxide of lead, but as large quantities of sulphurous acid are being evolved at the same time, the latter combines with the lead salts above named, and converts them into the sulphate.

The fume when given off from the furnace appears as a dense white smoke, which gradually deposits a fine powder varying in colour from white to grey; but even after passing through all the arrangements made for its collection a sufficient quantity usually passes up the chimney to render it a characteristic feature of a lead-smelting establishment.

For this reason the chimney-stack is generally removed to a considerable distance from the works, and if possible to some piece of mountain or waste land. Thus the great chimneys of Mr. Beaumont's works at Allenheads form a conspicuous feature in the landscape for many miles round, being erected on the very summit of the high moorlands which rise above the works. The lofty chimneys of Pembrey, situated on the waste lands close upon the shore, form in like manner, with their dense white smoke, an equally conspicuous object from any part of Carmarthen Bay.

The fume has usually, however, a considerable journey to perform before it reaches the exit into the open air. At Allenheads, for instance, the aggregate length of the flues is about 9 miles, one of them alone measuring more than 2½ miles. They are carried horizontally, or nearly so, for a considerable distance, and then rise with the hill until they reach the chimneys on the top. The flues are built of masonry, and are 8 feet high by 6 wide. Doorways are made at intervals, which are opened on the occasions when the flues are cleaned out; and on one of these occasions the quantity of lead fume which was collected from them yielded no less than 800 tons of metallic lead. The value of lead saved by this means at these works alone amounts to about £10,000 per annum.

Sometimes large chambers are placed at intervals along the line of flues with the object of aiding the deposition of the fume by reducing the strength of the draught; but the fume appears to be in so very finely divided a state that they exercise no perceptible influence upon the quantity of deposit, which seems most readily arrested by friction against the sides of the flue. This opinion is supported by the fact which has been frequently noticed, that those parts of the flue which may be wet from the percolation of water do not contain so large a deposit of fume as those where the masonry or brickwork is quite dry.

The first cost of flues of such enormous length, and the constant expenditure incurred in keeping them in repair, form no inconsiderable items; and various arrangements have been devised for artificially throwing down the fume, and so dispensing with the long flues. Some of them are found to work well, though the older plan still maintains its ground when the nature of the country is suitable; and in some cases a combination of the long flue and the condensing apparatus has been adopted with great advantage.

These artificial plans for condensing the fume almost always depend upon the agency of water applied in one way or another. They are called after the names of the inventors—Stagg's, Stokoe's, etc.; but it will not be necessary to go into all these in detail. In Stagg's condenser the fume is forced, by water or steam power, through water several times in succession, by making it pass through a chamber divided by horizontal partitions on the principle shown in the diagram (Fig. 1), in which A represents the level of the water, and B B B and C C C the two sets of partitions, the one set reaching nearly to the top, and the other nearly to the bottom below the surface of the water, so that the fume will have to take the course indicated by the arrows.

In Stokoe's condenser, on the contrary, the water scarcely reaches up to the partitions C C, etc., so that the fume does not actually pass through the water at the bottom of the chamber, but each division has two floors made of open woodwork, upon which fagots are laid, as shown in Fig. 2: streams of water pour down continuously from the pipes D D, which become broken into showers as they trickle through the fagots, presenting a large surface of water to the fume as it also passes through them. A fan-blast is of sufficient power to work this apparatus.

In others a layer of pebbles is substituted for the fagots, and again in others jets or showers of water are thrown at intervals into the condensing chambers. Some of them are said to do their work so thoroughly that no ill effects are produced by the smoke when it issues from the chimney.

The quantity of lead fume given off in the course of the smelting seems to vary very considerably; probably from differences in the nature of the ore, as well as in the treatment. The lead extracted from the fume frequently amounts to 7 per cent. of the total quantity of metal produced at the works, and sometimes even to more than this proportion.

As the fume when collected consists almost entirely of sulphate, it is generally smelted in a reverberatory furnace with the addition of some coal and about an equal quantity of scrap iron; but owing to the finely divided state of the fume it cannot be put into the furnace without being first agglomerated into lumps, which is done either by gentle heating until it just becomes soft, or by mixing it with lime paste.

The greater portion of the lead produced by the various processes already described is not of a quality fit for the manufacturer, and is termed hard lead, in contradistinction to the finished article known as soft lead.

The refining of the hard lead must now be described. This operation goes by various names, being sometimes called softening, and at other times calcining or improving. The hardness of the lead is due to impurities, amongst the most common of which is the presence of antimony and zinc; these metals form alloys with the lead, and so alter its character as to deprive it of some of its most valuable properties: they render it less manageable under the roller, diminish its power of resisting the action of the atmosphere, and interfere with the separation of the silver from the lead.

In order to get rid of these objectionable ingredients, the lead is melted in a reverberatory furnace with a shallow level hearth, and kept for some little time at a dull red heat, a good supply of atmospheric air being maintained throughout the operation. The dross, which consists of a mixture of the oxides of the various metals, including also some portion of the lead itself, is skimmed off as it accumulates on the surface, and the metal is tested from time to time to ascertain when it has arrived at a proper condition of softness. The right period is known by the peculiar iridescent and crystalline appearance of the surface of the test sample as it cools, which is easily recognised by an experienced workman. As soon as this point has been arrived at, which may be in the course of twelve hours, or on the other hand after three or four weeks if the lead has been very much contaminated, the whole of the dross is skimmed off, and the metal drawn from the furnace into a pot, from which it is again ladled into the pig-moulds.

In this, which is the ordinary process, the result is due entirely to the slow oxidation of the metals during the prolonged exposure in the furnace; but some manufacturers have preferred to add nitrate of soda, caustic lime, common salt, and other ingredients which assist in the separation of the impurities.

The dross skimmed from the surface of the lead during the softening, contains a large proportion of oxide of lead; and this is again reduced in either a reverberatory or blast furnace, some coal, and occasionally also a little soda ash, being mixed with the charge. This will yield a lead still harder, or in other words still more full of impurities, than that from which the dross itself was derived; but it may nevertheless be worth softening. This will yield a still inferior dross, which will no longer be of any value to the lead-smelter, though it may be turned to account by converting it into the antimoniate of lead, which is the pigment known to painters as Naples yellow. This product may be obtained by the simple calcination of the dross at a red heat; though the brilliance of the colour is said to be improved by the addition of a good quantity of common salt during the latter part of the process, or by subsequently exposing the calcined article to the action of acetic, hydrochloric, or sulphuric acid.

In the first article upon this subject, attention was drawn to the fact of this being the great lead-producing country of Europe; but it appears from the statistics compiled by the Government that the home consumption of this metal is somewhat in excess of the production. According to the official returns for the year 1868, the quantity used in this country was calculated at 78,000 tons, while the quantity derived from the ore raised within the United Kingdom was only 71,000 tons. The balance has to be made up by imports from abroad, either of the ore or of the metal itself. In the course of the twelvemonth a good deal of ore does come here from the Australian colonies and from foreign parts to be smelted; but although the produce of the country so nearly balances the home consumption, the total imports of the year above named amounted to 58,000 tons, and a large proportion of this was in the condition of pig-lead.

It seems anomalous that with all our advantages we should import such large quantities of the manufactured article, but the explanation will be found to lie in the fact that the pig-lead imported is the hard lead, which is brought to this country to be softened and subsequently desilverised. This is now a regular branch of trade carried on to a large extent on the banks of the river Tyne. The principal source of supply of this hard lead is Spain, where, though the ore is exceedingly abundant, the smelting processes are carried on under certain disadvantages, the ores being poor in quality and refractory in character, while fuel is so scarce in the lead-mining districts that the coke used in the smelting has to be sent out from this country.

The softening and desilverisation of foreign leads is an industry of recent introduction; in the year 1844 only 213 tons of Spanish lead were imported into Newcastle for this purpose; in 1852 this had increased to 7,317 tons; in 1862 to 12,459; and each succeeding decennial period bids fair to show a considerable advance upon the last. The lead contains on an average about fifty ounces of silver to the ton.

Pure lead is of a bluish-grey colour with a bright metallic lustre, but this is soon lost on exposure to the air. It is very heavy, the specific gravity being 11·35; but on the other hand it is so soft that it can be readily scratched with one's finger-nail. It can easily be rolled out into thin sheets, and these may be bent to almost any extent without breaking. It melts at about 620° Fahrenheit, and as compared with other metals is a very bad conductor of heat.

The facility with which it can be rolled out into flat sheets, and also pressed into the shape of hollow tubes, coupled with its pliancy, have led to its very extensive application in these forms. Moreover, this mode of using lead was well understood long before the means of rolling zinc into plates was discovered, and though much more expensive than the latter, it will certainly hold its ground against its modern rival on account of the ease with which it can be manipulated by reason of its pliancy. The sheet lead used in covering the roofs of houses, in making gutters, and in lining cisterns, together with the lead piping for conveying the water to the various parts of our houses, are familiar objects in every plumber's shop. The mode by which pig-lead can be made to assume these forms must be considered in the next article.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

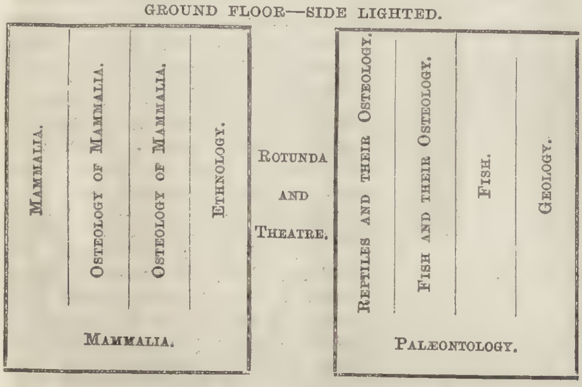
X.—NATIONAL MUSEUMS (*continued*).

6. *Construction.*—As affording a simpler type of construction, I prefer giving an ideal plan of a National Museum of Natural History, founded on the published views of Owen, Agassiz, Hooker, Sclater, Flower, Archer, Huxley, Wallace, etc., rather than the absolute designs of Mr. Waterhouse.

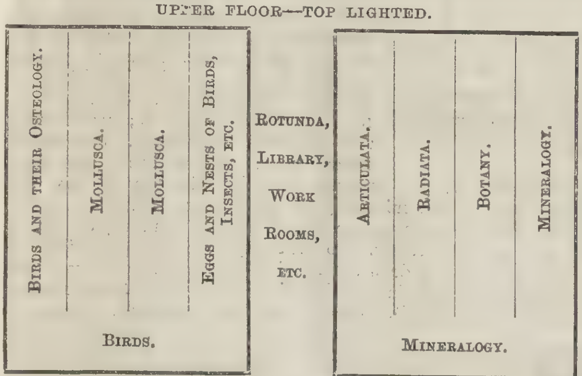
Before describing the complete building, it will be well to consider the leading ideas on the principles of construction that have suggested themselves to those naturalists who have given attention to the subject. First, as to date, is Professor Owen's plan of 1859, founded on the principles he had carried out in the construction of the new Hunterian Museum, built under his auspices during his conservatorship at the College of Surgeons, which answer the objects in view admirably—viz., the attainment of the perfect illumination of both wall and table cases by admitting daylight through windows placed in the angles formed between the walls and a flat roof, as shown at L in the section (Fig. 1). He considered that if space could not be given for the erection of the entire series of galleries on one floor, to allow of this principle of lighting being carried out, then light should be admitted by windows placed on each side of the lower galleries, immediately over the wall-cases, and to effect this he intersected the series of galleries with open courts 20 feet wide, as shown in the plan (Fig. 1). Professor Owen devoted the basement, B, to store-rooms, workshops for taxidermists, modellers, skeleton preparers, carpenters, etc. Over the basement he placed a range of galleries 30 feet high by 40 feet wide, with an average length of 150 feet, light being attained by the open courts referred to, C, C, of plan and section.

These side-lighted galleries he considered suited for the disposition of mammalia, reptiles, fish, ethnology, osteology, palæontology. Above the lower, he placed a second range of galleries, 25 feet high, lighted from the angles of the building, as at the College of Surgeons, which he deemed best fitted for the arrangement of birds, oology, mollusca, radiata, plants, minerals. The plan of 1862 consisted of a series of eight such galleries, 150 feet long, on each floor, with a rotunda for the lecture theatre, elementary collection, etc., in the centre, which were arranged thus:—

GROUND FLOOR—SIDE LIGHTED.



UPPER FLOOR—TOP LIGHTED.



In case of additional space being needed, the open courts could be covered in with arched glass roofs, at a height of 25 feet from the floor, so as not to interfere with the side windows of the lower galleries. Keeper's rooms and small studies were placed at the end of certain galleries, as indicated in K and S, in the plan (Fig. 1). It will be noted that the successive links in the chain of Nature are here arranged in broken or disconnected order, and that the requirements of the memorialists of 1858 are not complied with as to the direct blending of the osteological and palæontological with the recent specimens, or of the eggs, nests, etc., into the life-history groups of birds, insects, etc., though this is a matter of arrangement, not of building construction: the two subjects are so intimately connected that it will be advisable to call attention to it here.

Fig. 1—Section and Plan—gives a clear idea of Professor Owen's opinions on the construction of Natural History Museums.

Next we have Dr. Philip Lutley Sclater's* ideas (Fig. 2), as conveyed in a paper read before the British Association at Liverpool, September, 1870, entitled, "On Certain Principles to be Observed in the Establishment of a National Museum of Natural History." His plan is to arrange the building in the form of a hollow square, the external walls measuring some 600 feet by 400 feet, this external block being divided by a central wall or partition into two equal parts, the outer portion being devoted to the public galleries, the inner portion to the studies, keeper's and store-rooms, the centre of the hollow square being occupied by a circular building containing the library, having direct communication, by light iron galleries, with all the working-rooms, so that students of any department could obtain ready access to it and the lecture theatre. This museum might be of two, three, or four storeys, as the public galleries would be lighted by windows on the outer walls, and the studies, etc., by windows in the inner walls, the system of top lights being avoided. Dr. Sclater's plan of building will be readily understood on consulting Fig. 2. His system of arrangement must next be noted. Outside the partition that separates the studies from the galleries, he arranges a continuous line of wall-cases, for the display, in one unbroken series, of the "vertebrates, from the highest mammal to the lowest fish;" and so on, with the invertebrate, botanical, and mineralogical collections, or, as I suppose, in such manner as practical considerations might modify. The leading idea is that the fronts of these wall-cases should be hermetically glazed on the side exposed to the dusty atmosphere of the public galleries, and accessible only from the side next to the studies, to allow of any specimens required by students being removed from the cases containing the public series to the study-tables. This method had been previously suggested by Dr. Hooker, in a letter to the *Gardener's Chronicle*, as far back as 1858 (page 749 for that year); but as Dr. Sclater says, in a note to his paper, as published in *Nature*, for Oct. 6, 1870, "I can only, therefore, claim to be *an* (not *the*) original inventor of this method of arrangement." "These cases (says Dr. Hooker) should open from the back only, and then into smaller parallel side galleries, in which the naturalist might work undisturbed by the public." Further, he suggests that these cases should commence three feet above the floor, the space beneath being occupied by drawers, etc., opening into the back galleries, the space in the public galleries corresponding to the back of the drawers being utilised with diagrams, classifications, illustrative remarks for the instruction of the general public.

It will be observed that in Dr. Sclater's plan (Fig. 2) the wall-cases are reduplicated to obtain an extended range of wall-case in a gallery of limited length. Thus, as will be shown in Fig. 9, when in the ordinary way a wall-case would only present a frontage of 35 feet, by throwing out the cases 15 feet into the gallery, and doubling them on each other, a frontage of 95 feet may be obtained. To gain access to cases of this kind, it is necessary to provide a passage, at least 3 feet wide, nearly through the centre, to give access to the doors. It appears to me that the advantage gained by the hermetically closed fronts is to a great extent counteracted by the manner in which Dr. Sclater places these cases in the open public galleries, as the dust disturbed by the traffic would distribute itself over the top of the cases, and find access to the cases when the doors at the back were opened. It would be better to place these back close to the wall that separates the galleries from the studies, so that the backs of the cases formed the separating partition itself, and then it would be necessary to roof in the passages. This might be done by throwing a gallery over the projections, in a manner similar to that which may be seen at the Museum of Practical Geology, as indicated at G (Fig. 2); but the drawback therein experienced is the serious darkening of the cases at the end of each bay, and the increased difficulty of general supervision, as such covered recesses form covers for thieves and other objectionable characters, that, according to the evidence given before the Committee on Public Institutions,* must be provided against in our public galleries, especially those of great extent. The better plan would be to place the cases *at the end of the recesses*, under a beam or iron girder, stretching from pier to pier at 9 feet above the floor, of equal depth as such cases, say 3 feet, so as to bring the fronts flush with the upper part of the walls of the galleries, and the backs flush with the walls of the studies, then by roofing the projecting cases so as to cover the passages from the studies, the fronts would be really hermetically closed on the public side, and dust effectually excluded. My idea on this point is indicated at H (Fig. 2), and will be shown in detail in Figs. 7, 8. Dr. Wallace raises another objection to Dr. Sclater's plan, on the ground that the use of wall-cases on one side of a gallery for an entire museum is an expensive and wasteful principle of arrangement. The same might be said of devoting an equal width to the studies as to the public galleries, and on this point we might be guided

* Secretary to the Zoological Society of London.

* "Parliamentary Papers," Vol. XVI., 1860.

by Professor Maskelyne's opinion, that a depth of 25 feet from window to wall was essential for the instrumental requirements of the mineralogical private rooms.* Dr. Wallace raised other objections, but these were not associated with constructive details, and will be considered under the head of "Arrangements."

Typical Plan for National Museum of Natural History.—As Professor Owen's and Dr. Sclater's proposals embody the guiding ideas of British naturalists on museum construction, I will give the details of a plan that embraces the practical points of both systems. The main walls of the principal building would form a hollow parallelogram, as shown in Figs. 3 and 4. In elevation it would consist of a basement devoted to storage, workrooms, and workshops, wherein any operation *not requiring the use of fire or artificial light could be carried on.* The ground-floor would comprise the VERTEBRATE GALLERIES, 30 feet high by 50 feet wide, lighted by windows on the outer side, placed at 10 feet above the ground, and studies, store, and keeper's rooms, etc., running parallel with such galleries, in two tiers 15 feet high by 25 feet wide, lighted by windows looking out into the open court, with doors on the lower tier opening into the public galleries pertaining to the same CLASS of objects. The walls that separate the galleries from the studies being pierced to allow of wall-cases being employed in the manner shown in my next paper (Figs. 7, 8). All the lower tiers of studies would communicate one with the other by doors fixed in the walls that separate one CLASS from another, to give the student ready access from one CLASS to another. On the ground-floor a single-storeyed gallery, *lighted from above*, devoted to the proper display of birds, would intersect the open court. The upper floor would be arranged on the same principle, but be lighted entirely from above by angle windows. The galleries would be 25 feet high by 50 feet wide; the studies 10 feet high. This floor would be approached by wide staircases, S, S, at each end of the building, rising from the halls, H, H. Fig. 5 shows a section of the entire building, across B B, with the method of reflecting light into the windows of the basement, by means of white tiles placed at an angle. On entering at the main entrance, H, and turning to the left, the MAMMALIAN GALLERY (I.), 1,100 feet in length, would have to be traversed; then the AVIAN GALLERY (II.), 700 feet; the REPTILIAN (III.) and PISCEAN GALLERIES (IV.), with a united length of 1,100 feet; ascending to the upper floor the INVERTEBRATE GALLERY (V.), 950 feet long; next the Botanical Gallery (VI.), 200 feet long, with its Herbaria adjoining; then the Mineralogical Gallery (VII.), 500 feet; and the Gallery of Stratagraphical Geology (VIII.), 450 feet long, provides for the continuous survey of Nature from the mammal to the crystal, as required by the memorialists of 1858, and other naturalists. In front of this would stand the Rotunda, including on the ground-floor the theatre T, 76 feet in diameter. The galleries of Elementary Natural History and British Natural History are situated at E, E, and surround the circular building, to which light is admitted by side windows from the OPEN COURTS, C, C, C, C. The entrance-hall is at H, and at S are stairs leading to and from the upper floor, which contains the ethnological and geographical groups, arranged after the idea faintly indicated by the late Professor Edward Forbes at the Crystal Palace, in a domed rotunda, G, 150 feet in diameter, as required in Professor Owen's scheme, which also might contain, within the plane of the dome, as closely associated with geographical science, a large orrery, O, O, as in Fig. 6, which represents a section across A A. On each side of the rotunda are placed two blocks, the one on the right devoted to the reception-rooms and offices, D, of the director or superintendent, his secretary, etc.; and the private rooms, K, of the keepers of the zoological, botanical, mineralogical and geological departments; L, the lodge and apartments of the night guardian; and on the upper floor the library of general natural history, B. The left block is devoted to the lodge of the day guardian, L; refreshment rooms, R; guard-room and fireman's apartments, and watch-tower, F, F; and on the upper floor workshops, W, for purposes requiring the use of gas and fire; and M the mineralogical laboratory, lapidaries' room, etc. The lower rooms are lighted by side windows, the upper floors by angle lights. Covered ways for the protection of carriages on rainy days are provided between the wings of the two side buildings, indicated by the dotted lines between F and L and D and L (Fig. 3). Fig. 6, as we have remarked, represents a section across A A (Figs. 3 and 4).

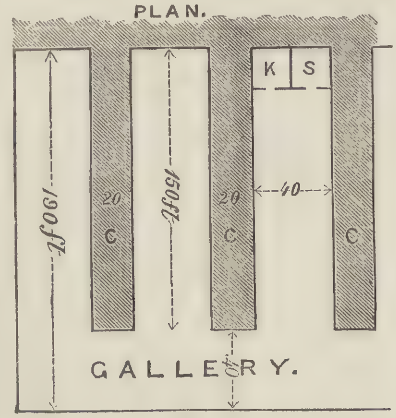
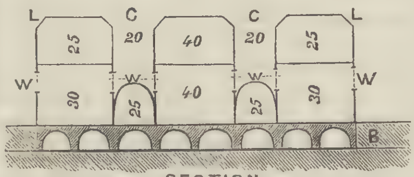


Fig. 1.



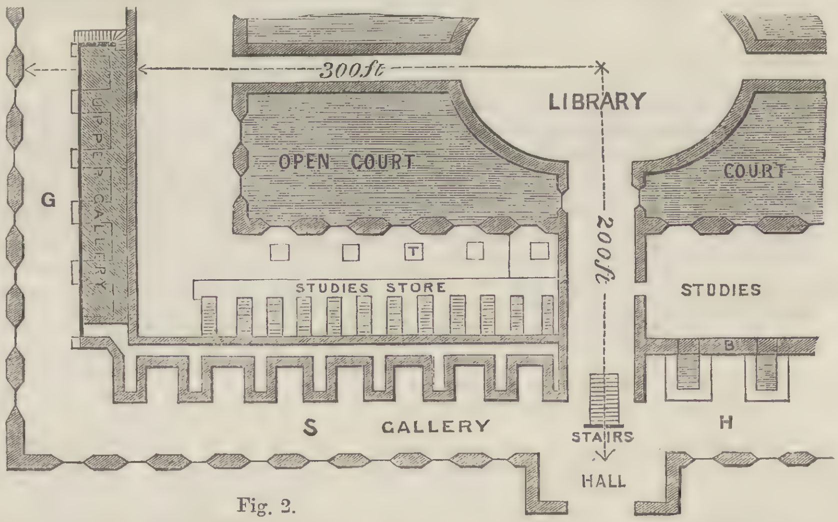


Fig. 2.

Provision against Fire.—At the present day houses for the keepers of certain departments are attached to the British Museum, but, as Professor Owen observes, "official residences, with servants, and especially with children, are elements of danger" to a national collection, he has not included space for such dwellings in his plans for a national museum. In connection with this observation, it may be stated that so greatly is risk from fire estimated by the present trustees of the British Museum, that though for years past Professor Maskelyne has urged the necessity for a small chemical laboratory, wherein the analysis of the minerals under his charge could be conducted, the trustees have uniformly declined to accede to that request, or allowed him, till within the last year or two, to temporarily rent, at small annual expense, an existing laboratory in the

* See "Committee on British Museum," Vol. XVI., 1860.

immediate neighbourhood, as one of their rules forbids a light or fire of any kind to be used within the walls of the museum, while another forbids any specimen to be removed from the building; so the keeper of the mineralogical collections has for many years been barred by the trustees from determining one of the most important characters of a mineral species or variety, though his scientific reputation was at stake on the matter of the correct naming of the specimens exhibited to the British public in their national museum.

The galleries of systematic natural history, as I have previously remarked, are planned for the perfect exclusion of artificial light and fire, provision being made for its being heated by hot-water systems, with isolated furnaces. The same rule would apply to the right-hand block, as containing the general library and the directors' and keepers' official documents, correspondence, official catalogues, etc. The left-hand block would be constructed with every provision against the extension of fire, should one occur, in laboratory, workshop, refreshment-rooms, or guardian's residences. The lecture theatre, the galleries of elementary natural history, of ethnology and geographical distribution, might be lighted by a gas system similar to that found to work so well in the South Kensington Museum. The supply-pipes should be arranged outside the building, with provision for instantaneously cutting off the supply by external main-taps. Gas properly arranged in a museum conduces to good ventilation, and causes less mischief than when there is less active ventilation, for on the gas being lighted at the South Kensington Museum on a hot summer's evening the temperature in the picture gallery has been decreased 2°, and the atmosphere of a crowded room at once materially improved.

In the Report of the Committee on Public Institutions previously cited, a curious result of some experiments on fugitive pigments is recorded. A series of sensitive tablets were prepared of uniform character, and distributed amongst certain public and private buildings. The most deteriorative effects were produced in the uninhabited National Gallery, the next worst place was an open country privy; the mischief at the former place being caused by the sulphuretted hydrogen emanating from the crowded visitors in a badly-ventilated gallery. The least effect was produced where perfect ventilation was attained by up-currents, caused by gas "sun-burners" placed in the roof of the building. The condensed gas lime-light apparatus, specially arranged for museum purposes, which has been described in this work in "Optical Instruments—Sources of Artificial light," may be advantageously and safely adopted in illuminating, as it presents the additional advantage of producing a light that exhibits *objects in their natural colours!*—a matter Dr. J. E. Gray considered unattainable by artificial illumination.

It will be noted that the rotunda and supplementary blocks are separated from each other, and this group isolated from the main building by a distance of 100 feet. Hydrants should be distributed around and within the buildings, not only for the purpose of providing against accident by fire, but also for keeping the external walls, courts, and surrounding grass-plots, pavement, etc., free from dust and smoke. The grass-plot, it is true, is not large in superficial area when compared with the great size and extent of the building, and its length makes it appear in the plan to be much narrower than it actually would be. It is, however, large enough for all practical purposes, and is, moreover, all that the space at command will allow, though the building itself would look better if it were larger.

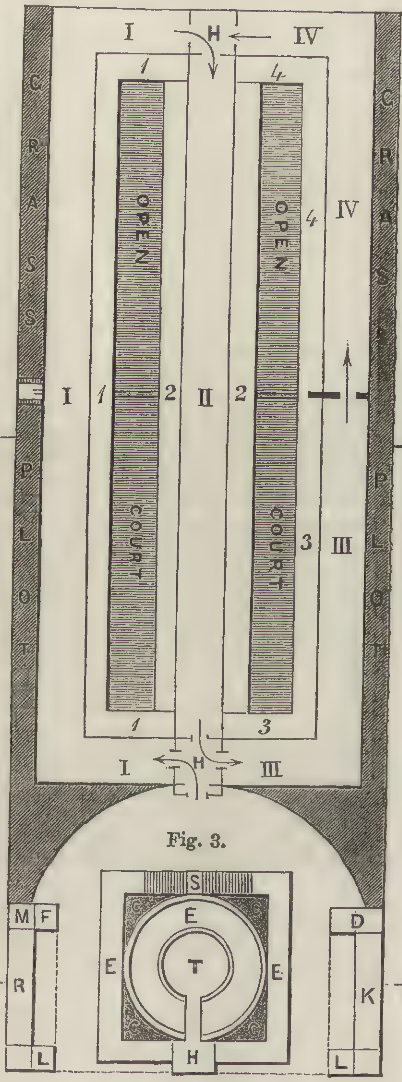


Fig. 3.

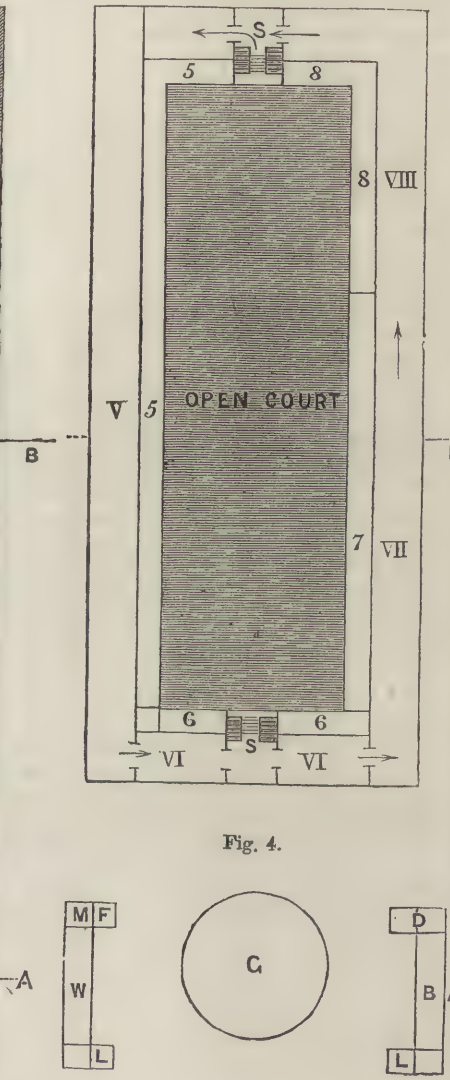


Fig. 4.

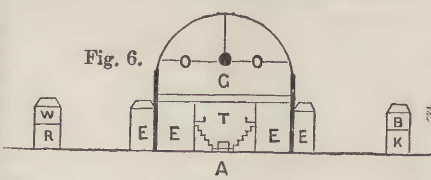


Fig. 6.

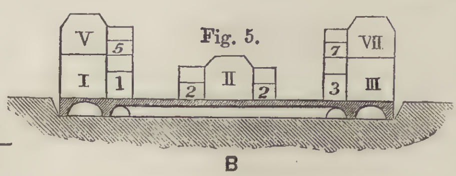


Fig. 5.

SEATS OF INDUSTRY.—XXX.

BRISTOL (*continued*).

BY WILLIAM WATT WEBSTER.

AMONG the enterprising Bristol merchants who contributed to the fitting out of the expeditions of the Cabots, one of the most noteworthy was Robert Thorne, who claimed descent from Huldrich the Torn, uncle of Rollo, Duke of Normandy, and whose ancestors held the office of standard-bearers to the Norman house down to the conquest of England, and afterwards distinguished themselves in a variety of ways in this country. Several of his progenitors were cloth manufacturers and cloth merchants, and this would seem to have been Robert Thorne's chief trade, although at the same time he was an extensive dealer in white soap, which next to woollen cloth was the principal article manufactured in Bristol towards the close of the fifteenth and during the early part of the sixteenth centuries. Robert Thorne was appointed, along with fourteen others, to hold in commission the office of Admiral of England at Bristol in 1510, and in 1515 he was elected mayor. He represented Bristol in Parliament in 1523, and is supposed to have died a few years later, leaving his wealth to two sons, who also inherited much of their father's enterprise and public spirit. When Sebastian Cabot sailed with three ships and a caraval from Seville in 1526, on the voyage that resulted in the discovery of the river La Plata and the exploration of the adjoining districts, he carried with him the agents of various merchants whose ventures were estimated at a total of about 10,000 ducats, of which sum 1,400 ducats were contributed by Robert Thorne the younger and his partner in Seville. Returning to England in 1527, Robert Thorne the younger urged upon Henry VIII. the importance of prosecuting the work of discovery, especially towards the north, "the which," he argued in a letter to the king, "it seemeth to me, is only your charge and duty; because the situation of this your realm is thereunto the nearest and aptest of all other, and also for that you have already taken it in hand." In May of the same year "King Henry VIII. sent two fair ships well manned and victualled, having in them divers cunning men to seek strange regions," but the voyage was not prosperous. Robert Thorne the younger amassed great wealth, and his benefactions were liberal and wisely divided. Besides devoting a large sum of money to the rebuilding of Walthamstow church, supposed to have been originally erected by his ancestors in the eleventh century, and expending a smaller amount in founding a scholarship at the Merchant Taylors' school in London, this patriotic merchant bequeathed £300 for the purchase of a site for a grammar school at Bristol, £308 for the formation of a fund for buying corn and wood when they were cheap and selling them to the poor of Bristol at cost price when they were dear, and £500 which was to be lent in small amounts, interest free, to needy and deserving clothiers of the town. His brother Nicholas was also a benefactor of the Bristol Grammar School, and shared in the trading expeditions to the New World that laid the foundation of our colonial empire. Towards the end of the year 1534, it is recorded that King Henry "came disguised to Bristol, with certain gentlemen, to Master Thorne's house, and secretly viewed the city, which Master Thorne showed him; and he said to Master Thorne, 'This is now but the town of Bristol, but I will make it the city of Bristol.'" On the dissolution of the monasteries in 1540, Bristol, which till that date had been included in the diocese of Salisbury, was made the seat of a bishopric, and the conventual church of St. Augustine, which was saved from the Iconoclasts through Nicholas Thorne's intercession with the king, was made the cathedral. This merchant served Bristol in the capacity of member of Parliament in 1537, and as mayor in 1545. About the latter date Bristol furnished twelve ships for the war with France in which Henry VIII. was then engaged, the three largest vessels being the *Thorne* and the *Pratt*, each of 600 tons burden, and the *Gournay* of 400 tons, so called after the merchants at whose cost they had been built. The inscription on the magnificent tomb erected to the memory of Nicholas Thorne in St. Werburgh's describes him as "a famous and upright merchant, whose words were governed by truth, and whose deeds were ruled by justice and by virtue, whom the whole community of Bristol acknowledged as a munificent father; for by his bounty they were blessed."

During the reign of "Bloody Mary" three Protestant martyrs were burned at the stake at Bristol. Four ships were dispatched from the port in 1588 to join the fleet that was sent to oppose the Spanish Armada, and in 1574 Queen Elizabeth visited the city. When Sir Humphrey Gilbert asked the queen in the latter year to sanction an expedition of discovery and trade to the northern parts of America, "of all unfrequented places the only most fittest and most commodious for us to intermeddle withal," as he said, and "fatally reserved for England and for the honour of her Majesty," we find that "the city of Bristol very readily offered £1,000" out of the £4,000 required for the undertaking. The merchants of Bristol played a prominent part in the settlement of Virginia, and also in that of the more northern colonies. Three years after the issue of the patent for New England, which is dated 1620, James I. wrote to the authorities of Bristol and Exeter, requesting them "to move persons of quality to join in the advancement of that plantation, a work in which the public take great interest and likely to bring in good returns;" and Bristol readily complied with the request. Documentary evidence has been preserved of the early connection of many of the merchants of the city with America. A petition dated 1638, and signed by "Walter Barrett, Walter Sandy and Co. of Bristol, merchants," sets forth that "they have been many years settling a plantation in New England which was begun long before such multitudes of people went over; all they intend to send are regular people, neither factious nor vicious in religion; their plantation is apart from all others, and they desire to transport 180 persons; to provide victuals for furnishing the ships employed in the fishing trade upon that coast, for which they have built and made ready two ships." In 1651, "Lieutenant-Colonel Robert Yeomans and other merchants of Bristol, owners of the *Mary and Francis*," obtained permission from Cromwell's Council of State to accompany the fleet going to Barbadoes, "upon giving security to the value of the ship and goods that she does not depart from the fleet or trade with any in defection from the Commonwealth;" and in 1657 leave was given to Mr. Ellis, of Bristol, to send 1,000 dozens of shoes to the island of Barbadoes in January, and another 1,000 dozens in December. By a Commonwealth order of 1652, "liberty was given to Henry Hazard and Robert Yeomans, of the city of Bristol, merchants," to quote from Sainsbury's "Calendar of State Papers, Colonial Series," where the above particulars are also to be found, "to carry 200 Irishmen from any port in Ireland to the Caribbee islands!" It was from Bristol that William Penn sailed in 1682 for the New World. Being peculiarly affected in the controversy about ship-money, Bristol naturally espoused the cause of the Parliament in the Civil War, and was garrisoned by a body of the popular troops. It was besieged by Prince Rupert in 1643, and surrendered within three days through the treachery of the governor, Nathaniel Fiennes. For two years the royalists held the city, but it was assaulted and captured by Fairfax in 1645, when the castle was dismantled and the fortifications destroyed by order of the Parliament. After the restoration of Charles II., some of the inhabitants of Bristol would appear to have been affected by the reaction against Puritanism that then set in. There were two parties among the merchants of the city, and the strife was carried on with great warmth. After serving as Recorder of Bristol for twenty-one years, Sir Robert Atkins said in 1682, "I did all I could to join them together and unite them; for ever since they grew rich and full of trade and knighthood—too much sail and too little ballast—they have been miserably divided." The moral condition of the city at this period is described in the following terms by another citizen:—"Vice, profligacy, and a disregard of civil and moral obligations had entered the city and taken possession of her high places. The sacred fount of justice was polluted, her laws violated, and religion herself, in her holiness and her purity, was degraded to an instrument of cruelty, oppression, and wrong. In their abundance the people had forgotten the God they had acknowledged in their extremity. In their elevation, pride and the lust of power had supplanted the meekness and humility with which they were clothed in their adversity. They cared not to traffic with the bodies and souls of men, so that they supported their state and maintained their rule." The latter sentence of this heavy indictment refers to the share that Bristol merchants had in the African slave-trade, which was first added to the list of English trades by Sir John Hawkins, one of the famous Devonshire sailors of Queen Elizabeth's time, although it had been carried on upon an extensive scale by

the Spaniards and the Portuguese for more than a century previous to that date. Bristol was greatly enriched by its participation in the slave-trade, and continued to prosecute it with ardour till the suppression of the iniquity in 1807. Between the years 1795 and 1804, Bristol merchants shipped a total of 10,718 negroes from Africa to America and the West Indies.

Among the merchants who flourished in Bristol in the end of the seventeenth century, the most famous was Edward Colston, the last of a family that had been connected with the city since the year 1400, and several of whose members had filled important offices. It is chiefly as a philanthropist that Edward Colston is remembered. The first forty-five years of Colston's life were spent in London, but after the death of his father, which took place in 1681, he settled in Bristol, and carried on the business he had inherited, which consisted principally in sending ships to the West Indies with English goods, and bringing home sugar and other commodities. In 1689 he and his partners, Richard Beacham of London, Sir Thomas Day, and a Captain Nathaniel Wade, who had in his youth gone to New Jersey to form an ideal colony, and more recently had been implicated in Monmouth's rebellion, set up a sugar refinery at an old house known as the Mint, and in that year Colston took up his abode in the quaint house at Mortlake, still standing as a ruin, where Oliver Cromwell had lived before him. The benefactions of this merchant are too numerous to record. Every year he went through Whitechapel prison and the Marshalsea to empty his purse in freeing the most deserving debtors incarcerated for small sums, and in one case he sent £3,000 to liberate the poor debtors in Ludgate prison. He gave £20,000 to relieve the starving poor of the city of London in 1709, a year of famine, and in the following year he was returned as member of Parliament for Bristol, although he protested that he was too old to discharge the duties of that position, being then in his seventy-fourth year. Edward Colston's charities were so numerous and so munificent that they roused the jealousy of his brother citizens. In 1702, when he proposed to increase the number of Queen Elizabeth's Hospitallers from 50 to 100, the Bristol aldermen at first refused the gift, and denounced the institution as "a nursery for beggars and sloths, and rather a burden than a benefit to the place where they were bestowed," a criticism, however, that may not have been altogether devoid of truth. In 1707, Colston founded an hospital with school attached to it, in which about 100 boys are educated, maintained for seven years, and then apprenticed. He died at Mortlake in 1721, at the age of eighty-five.

When Queen Anne visited Bristol in the beginning of the eighteenth century, the splendour and cordiality of the reception she received made so great an impression on her that she said, "I never knew I was a queen till I went to Bristol." The charter of the city was confirmed by this sovereign. It was from Bristol that Dampier sailed on the voyage in which he fell in with Alexander Selkirk, the prototype of De Foe's "Robinson Crusoe." The history of the city throughout the eighteenth century is marked by few prominent incidents; but we may state that in 1761 Bristol contained nearly 100,000 inhabitants, and in 1799 there were twenty sugar refineries in the town, and no less than seventy full-sized vessels belonging to the port were engaged in the West India trade, sugar and negroes being then the staple articles of Bristol commerce. Serious bread riots took place in Bristol in 1753, and other disturbances broke out in connection with an agitation for the abolition of the bridge-toll in 1792. The most notable of the merchants of Bristol at that time were William Miles and his son Philip. In his interesting and elaborate work on "English Merchants," Mr. H. R. Fox Bourne gives the following account of the early history of William Miles:—"Somewhere near the year 1760—so the story goes—William Miles walked into Bristol with three-halfpence in his pocket, and a resolution to use his ready wit and his strong arms in advancing his then very slender fortunes. Taking the first porter's job he could meet with in the streets, he earned sixpence thereby. With fourpence he managed to buy food enough for the day, and to find some sort of lodging for the night. Next day he earned more, and earning each day more than he spent, he worked on as a street porter till he had saved a sum of £15. With that he apprenticed himself for three years to a carpenter and joiner, and during those three years he earned some more money and gained some further experience by doing evening work for a small ship-builder in the neighbourhood. He thus qualified himself, when his apprenticeship was over, for going out as a ship's carpenter in a Jamaica merchantman. While in Jamaica he applied his little savings in buying a cask or two of sugar, for which he was allowed free passage to Bristol, and while there he managed to sell at a considerable profit. With the proceeds he procured a little stock of such articles as he thought there was the best market for in Jamaica. So he went on, from each voyage earning more money, and enabling himself to carry on a larger traffic. Thus he came to be known on both sides of the Atlantic as a man of remarkable energy and honesty, and as soon as he had capital enough he settled down as a merchant in Bristol with certainty of success. So well did he succeed that in 1795, when his son Philip John, then twenty-one years of age, proposed to marry a daughter of the Dean of Lismore, he was rich enough to hand him a cheque for £100,000, and so, it was said, to remove the opposition of the aristocratic clergyman to association with the family of a self-made man." The son was a partner in his father's business, and carried it on after his father's death in 1805. Although he lived in princely style and spent his money freely, Philip Miles left personal property, at his death in 1848, valued at upwards of a million sterling. Conrad Finzel, a native of Frankfort, was an eminent Bristol merchant contemporary with the younger Miles, whose career was even more remarkable than that of the elder Miles. Flying from his native country to escape the conscription, Conrad made his way to London, where he found employment in a sugar refinery, and soon rose to be second boiler in the establishment, and which he left to become principal refiner in a sugar-house at Bristol. By 1836 he had earned and saved enough money to enable him to join with a partner in the working of a small refinery in Counterslip, on the site of which now stands the largest sugar refinery in the world, built in 1846 at a cost of £250,000, which yields 1,000 tons per week, and gives constant employment to more than fifty large West Indiamen. This establishment belongs to Messrs. Finzel, Son, and Co. Besides the profits of his own works, Conrad Finzel, during the latter years of his life, derived an income of about £10,000 a year from royalties paid to him by other refiners for the use of the vacuum pan and centrifugal vat for making crystals, which he had invented and patented. This merchant prince bestowed his means lavishly on charities of all sorts, and especially on the Orphan House established at Ashley Hill by his countryman, the Rev. George Müller, his gifts to which amounted during several years to £10,000 per annum. He persistently refused to accept any public function; and when elected as an alderman without his consent, he replied to the urgent entreaty of some of his fellow-citizens to serve the city in that capacity—"God gave me a faculty to be a good sugar-boiler, but no turn or talent to be a town-councillor." Conrad Finzel died at Wiesbaden in 1859, while on a visit to his native land.

PRINCIPLES OF DESIGN.—XXXI.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

STAINED GLASS.

In the Earthenware or Majolica Gallery of the South Kensington Museum a number of windows have been placed bearing subjects illustrative of the potter's art in various times, which are drawn in black on a plain light glass. Some of these are excellent, and most of them are well worth seeing.

Nearly twenty years since, when a comparatively young student at art, I was struck with the beauty of the frost on the window-pane such as we commonly see in winter on the glass of our sleeping-room windows, and was led to make sketches of some of the more beautiful forms. Ten years later I founded a style of window decoration on these sketches, and to this day I regard some of the patterns which I produced from these sketches as consistent and desirable enrichments for stained glass, and as my favourite works. Of these designs one was engraved (Fig. 143) in my last article. If this pane of glass be formed of a pale amber sheet of rich cathedral glass with the pattern drawn boldly in black, it will be such as I think satisfactory. Instead of the whole being formed of one piece of glass, the various parts may be differently tinted, and the whole leaded together, if colour is desired.

In the present chapter I engrave another design of a somewhat similar character, but consisting chiefly of curved parts (Fig. 146). Of the two I prefer the former and more simple treat-

ment, but when considered together, the two may give rise to a new style in domestic window glass.

In the last chapter I also gave an illustration of a bordering (Fig. 144), such as might be placed round a plain sheet of plate glass: this border would give colour and decorative effect, and its treatment I regard as correct. It is often desirable to form a window of small parts, or quarries, and if these are well managed very effective windows may be produced. These quarries may be enriched with conventionally treated plants, where the entire plant may be of one colour, and the background of another (old quarries are often met with bearing a flower, or a bird, or an animal, simply and conventionally drawn in outline on a pale green-grey glass, and having the figure filled with a yellow tint), or the flowers may be separated from the foliage by a third tint. Fig. 147 is an adaptation of the fuchsia, and Fig. 148 of the corn cockle (*Githago*), and in this last instance the leaves are arranged into the figure of the fleur-de-luce. Fig. 149 is only of floral character, but is not founded on any particular plant. Fig. 150 is after the type of the lotus bud. Fig. 151 is less floral in character, but retains a little of the vegetable type, while Figs. 152, 153, and 154 are wholly conventional in character.

Although I have occupied my space chiefly with illustrations, I may be excused for adding a few more remarks on art in glass painting, proceeding by saying, that if a window is placed in a very sunny situation, where it is intended to act in part as a blind, the introduction of a considerable amount of black, as in Figs. 147 and 149, is sometimes desirable, and certainly gives great force to the pattern.

To return for a while to Fig. 143, we have already remarked that the strong black lines of the pattern would look very effective when drawn on a pale amber-tinted sheet of cathedral glass. The effect of this may be ascertained approximately by drawing the design on a thin piece of lemon-coloured paper, and holding it up to the light, or even fixing it to a pane of glass. It must be remembered, however, that it will be impossible by this simple contrivance to gain anything more than an approximate idea of the actual appearance of the pattern when drawn on glass of the tint suggested, as the glass affords a transparent medium, while the paper is opaque, or partially so. The design may be applied in a variety of ways. It is suitable for a long, narrow, lancet-headed light, in which the pattern may be repeated thrice or four times, as shewn in the figure; the pointed pane at the top of the light being filled with the lower part of the design, which is confined by two curved lines springing from either side of the base, and meeting in a point a little above the actual centre of the drawing, as it is figured in the diagram. If the light be broad enough, the three or four sheets thus treated may be surrounded by a narrow border, in which, on a black ground, might be depicted amber leaves springing from a continuous stem running up the centre of the border, and turned alternately in opposite directions. Such a border would be in harmony with the central part of the window, the tints used for pattern and ground in the one being simply reversed in the other; but if it be preferred, there is no objection to the use of deeper and richer colour in the border, though, if this were done, the colour used should present a satisfactory contrast to the tint on which the pattern is delineated, as without strict attention to this, the effect produced will be far from pleasing to the eye. The same design may be used in sheets of glass placed side by side, as, for example, in the four window-panes frequently used to form the centre of a glazed door, and surrounded by panes of less width.

Fig. 146.

The border shown in Fig. 144 is adapted for the enrichment of a window, of which the centre is comparatively plain and simple in design, and devoid of much colour, as in the window shown in Fig. 145. Such a border presents a rich and beautiful effect when painted in three different tints of the same colour, the portion that is perfectly black in the design being painted in the darkest of the three tints—a tint, in short, approaching very nearly to black, or being the darkest possible shade of the colour used; while that which is white in the figure should be of a very light tint of the colour, and the part that is shaded of a tint forming as nearly as possible a mean between the darkest and lightest tint used. Another satisfactory mode of treating the design would be to allow the parts shown in black and white in the figure to be black and white in the painted copy as well, and to colour the shaded portions in any single tint forming a mean between black and white, that would be in harmony or pleasing contrast with the colours of the centre round which the border is disposed. The same mode of treatment will apply in an equal degree to the colouring of the figures given with the present chapter, and we may point out here, what may have already occurred to many of our readers, that a beautiful window may be formed out of Fig. 146 simply by repeating the design and border, so as to form a symmetrical pattern on either side of the central line, which, in case of a duplication of the design in this way, would be the line that now forms the boundary of the pattern on the right.

In forming designs for quarries, or small diamond-formed pieces of glass, similar to those shown in the opposite page, it is useful to search for plant-forms either common or peculiar to the neighbourhood in which the work is intended to be placed. In every district something worthy of conventional treatment may be found, and it is as right and necessary to use such forms for decorative art, whether in colour or carving, as it is wise in building to avail oneself of the building materials that the district yields.

Fig. 152.

Fig. 147.

Fig. 151.

Fig. 149.

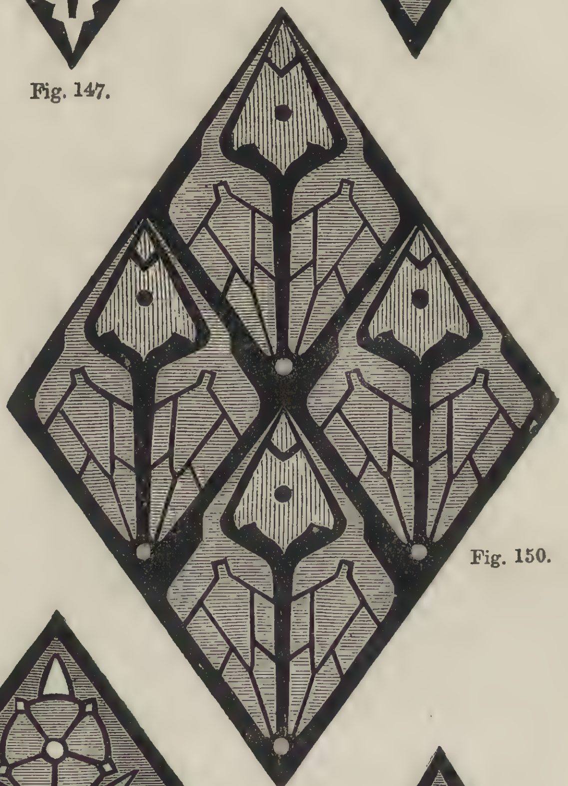


Fig. 150.

Fig. 153.

Fig. 148.

Fig. 154.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVIII.

BY E. WYNDHAM TARN, M.A.

BILL OF QUANTITIES (*continued*).

TILER AND SLATER.

SQR.	FT.	
$10\frac{1}{3}$		Supl., plain-tiling, showing 4 in. on face, double fir laths and wrought nails .
$8\frac{4}{5}$		,, pantiling, 10 in. gauge, bedded in mortar and pointed . . . . . .
9	44	,, Countess slating, $2\frac{1}{2}$ in. lap, each slate with 2 $1\frac{1}{2}$-in. copper nails . . .
$9\frac{1}{4}$		,, asphalted felt, laid under slating .
FT.	IN.	
30	0	,, $\frac{3}{4}$-in. sawn slate shelf, planed . .
61	9	,, flat roof of 2 courses plain tiles in cement . . . . . .
28	0	Run, heading plain tiling to bargeboard .
28	0	,, ditto, pantiling, ditto . . . .
31	6	,, ornamental ridge tiling in cement . . .
28	0	,, cement filleting . . . . . .
45	0	,, hip and ridge tiles in cement to pantiling
45	0	,, sawn slate hip and ridge, fixed with white lead and copper screws . .
24	0	,, rounded nosing to $\frac{3}{4}$-in. slate shelf . .
		Number—
		2 hip-hooks and painting 3 oils . . . .
		Carried to summary . . . £

MASON.

FT.		Kentish Rag—
187	6	Cube stone in bondstones . . . . .
YDS.		
132		Supl., 24-in. rough random walling . .
$131\frac{1}{4}$		,, ditto coursed ditto . . . .
274		,, pointing in blue ash mortar . .
FT.		Portland Stone—
757	8	Cube stone rough . . . .
8	4	,, ditto landings . . . . . .
46	6	Supl., 3-in. balcony . . . . . .
93	7	,, sawing . . . .
614	10	,, plain bed . . . .
710	5	,, plain work . . . .
133	5	,, sunk ditto . . . .
371	11	,, moulded ditto . . . . . .
13	1	,, circular ditto . . . . . .
75	5	,, ditto sunk ditto . . . . .
11	10	,, ditto moulded ditto . . . .
39	0	Run, lintels 9″ × 9″, in 6 ft. 6 in. lengths .
17	10	,, groove for lead . . . . .
83	3	,, chamfer . . . .
7	6	,, cutting and pinning to landing . .
96	8	,, throating . . . .
6	0	,, joggle to 3-in. landing . . . .
		Numbers in Portland—
		2 carved capitals to design . . . .
		4 mitres to cornice, 27 in. girt . . .
		2 stopt ends to ditto . . . . .
		20 mortise holes . . . . . .
		30 holes for balusters . . . . .
		17 ends of steps, cut and pinned into wall .
		28 plugs . . . .
		30 slate dowells . . . . . .
		24 lbs. lead for running plugs . . .
YDS.		Yorkshire stone—
$12\frac{3}{4}$		Supl., $2\frac{1}{2}$-in. tooled paving . . . .
FT.		
58	6	,, 3-in. templates and core for cornice .
31	6	,, ditto rubbed hearths . . . .
11	3	,, 7-in. sink . . . .
26	0	Run, sill 9″ × 3″, weathered and throated .
51	0	,, coping, 12″ × 3″, ditto . . . .
43	0	,, cutting to edge of $2\frac{1}{2}$-in. paving . .
		Numbers in York—
		12 fair ends to sills . . . . .
		2 ditto coping . . . . . .
		1 rounded corner to 7-in. sink . . .
		1 rebated hole ditto . . . . .
YDS.		Pavior—
$41\frac{3}{4}$		Supl., Elland edge pitching in sand and grouted
FT.		
30	0	Run, granite curb, 12″ × 6″ . . . .
		Marble—
21	0	Supl., 2-in. polished slab . . . . .
15	2	,, 1-in. ditto . . . .
		Number—
		4 console chimney-pieces, value 10 gs., P. C.
		Carried to summary . . £

CARPENTER.

FT.		
36	0	Cube, fir, use and waste in shoring . .
32	8	,, ditto, bond, plates, etc. . . .
138	3	,, ditto in single joists . . . .
135	3	,, ditto, framed in trusses . . .
56	4	,, ditto, girders, sawn down, reversed and bolted . . . .
4	7	,, ditto, proper doorcase . . . .
0	9	,, oak, weathered sill . . . . .
113	9	Supl., centering to vaults and arches . .
135	0	,, bracketing to cornice . . . . .
481	6	,, planing fir . . . .
60	0	,, 1-in. deal gutter-board and bearers .
27	6	,, ditto, feather-edged louvre boarding .
23	5	,, $1\frac{1}{2}$-in. ridge piece. . . . .
SQR.	FT.	
5	88	,, $\frac{3}{4}$-in. battens, $3\frac{1}{2}$-in. wide, laid for Countess slates. . . . . .
2	41	,, ditto, $2\frac{1}{4}$-in. ditto, 10-in. apart, plugged to wall . . . . . .
3	60	,, 1-in. sound-boarding on two fillets. .
3	61	,, ditto, weather-boarding . . .
RODS.	FT.	
16	0	Run, 5 feet cleft oak pales, 2 arris rails, with oak posts 9 feet apart . . .
FT.		
265	0	,, 1-in. oak plank, 12-in. wide, to fence .
265	0	,, ditto, capping, ditto . . . .
49	0	,, tilting fillet . . . .
24	6	,, 2-in. ridge roll . . . . . .
24	0	,, herring-bone strutting . . . .
14	0	,, turning pieces $4\frac{1}{2}$ ins. wide . . .
21	6	,, $\frac{3}{4}$-in. deal arris gutter, 4 in. deep . .
10	3	,, ditto water-trunk, $4\frac{1}{2}$ in. square . .
12	6	,, circular head to window frame, glued in thicknesses, 5″ × 3″ . . . . .
		Numbers—
		1 shoe to water-trunk . . . . .
		2 joints, ditto . . . .
		1 hopper-head, ditto . . . . .
		6 blocks to purlins . . . . .
		24 wood bricks . . . .
		4 angle-pieces to bracketing of cornice 18 in. girt . . . .
		4 drips to gutter . . . . . .
		2 cesspools, ditto . . . . . .
		2 oak posts, 12″ × 12″, 5 feet high . .
		1 5-bar field gate, 9 feet wide, with sawn rails
SQR.	FT.	Sawyer—
1	96	Supl., sawing fir . . . .
0	240	Run, ditto, 6 in. oak rails . . . .
		Carried to summary . . £

JOINER AND IRONMONGER.

SQR.	FT.	
2	17	Supl., 2 cut white batten folding floor . .
1	87	,, $1\frac{1}{4}$ in. yellow ditto, straight joint, ditto
1	96	,, ditto, with iron tongues . . .
FT.		
15	9	,, deal-cased frames, oak sunk sills, $1\frac{1}{2}$ in. ovolo sashes, double hung with brass pulleys, white lines, and iron weights.
22	0	,, deal-cased frame, oak sunk and weathered sill, 2 in. deal lamb's-tongue sash, doublehung, brass pulleys, patent lines, and iron weights . .
29	3	,, ditto, 2 in. ovolo sash, ditto . .
35	9	,, solid oak rebated and moulded frame, 4″ × 3″, mullion and transom, mitred, beaded, and weathered sill, 2 in. lamb's-tongue casement, circular on plan, $\frac{1}{4}$-in. rise to the foot . .
7	0	,, 2 in. oak ovolo fanlight, circular head .
16	6	,, $1\frac{1}{4}$ in. deal 2 panel square door . .
16	6	,, ditto, 4 panel moulded and square ditto
17	11	,, $1\frac{1}{2}$ in. ditto, square ditto . . .
42	3	,, 2 in. ditto, moulded both sides, ditto .

26	3	,,	2¼ in. oak 6 panel bolection, moulded ditto, lower panels bead flush
35	9	,,	1¼ in. deal 2 panel bead flush, and square shutters, hung with brass pulleys, patent lines, and lead weights
15	2	,,	ditto, moulded and bead flush, folding ditto
13	0	,,	ditto, bead flush and square back-flaps
10	3	,,	ditto, proper boxings
105	4	,,	deal revolving shutter, with worm and wheel gearing
66	0	,,	1½ in. yellow deal treads, and 1 in. risers, glued and blocked to close-string, moulded nosing and two fir carriages
19	3	,,	ditto, ditto, winders
69	11	,,	1½ in. yellow deal treads, 1 in. risers, mitred to cut-string, glued and blocked, with moulded nosings, and 2 fir carriages
17	11	,,	ditto, winders
13	9	,,	ditto, rebated and beaded outer string, cut and mitred to risers
1	6	,,	ditto, writhe
11	11	,,	ditto, close-string
35	0	,,	ditto, wall ditto
19	0	,,	ditto ramp
21	11	,,	¾-in. deal, wrought 1 side and framed
2	3	,,	ditto, and beaded
8	0	,,	ditto, rebated and beaded
7	6	,,	ditto, both sides, and dovetailed
14	0	,,	ditto, tongued
31	8	,,	inch deal, wrought 1 side and tongued.
66	1	,,	ditto, and rebated
29	9	,,	ditto, square skirting
30	5	,,	ditto, torus ditto
7	11	,,	ditto, 1 side framed, moulded in 1 panel
21	9	,,	ditto, keyed frieze, joints feather-tongued, rebated for soffit
26	8	,,	ditto, wrought both sides
3	0	,,	ditto, framed and beaded
8	3	,,	1½ in. wrought 1 side, framed, moulded in 2 panels
9	7	,,	ditto, 1 panel
26	4	,,	ditto, both sides
42	3	,,	ditto, framed and beaded
7	6	,,	ditto, cut and diminished
19	0	,,	ditto, moulded and square framing
5	0	,,	ditto, ditto, circular on plan (½-in. rise to the foot)
22	9	,,	ditto, spandril
53	9	,,	ditto, moulded and rebated skirting, in two heights
12	10	,,	1½ in. deal, wrought 1 side, double rebated and beaded
21	11	,,	ditto, framed and moulded
18	2	,,	2 in. deal clamped dresser top
43	6	,,	cradling to entablature, ploughed and tongued blockings
24	0	,,	moulded cornice
7	0	Run,	½-in deal, wrought stop
7	8	,,	¾-in. ditto chamfered fillet, 2¼ in. wide
40	6	,,	ditto, skirting grounds, plugged
7	9	,,	ditto bead
43	0	,,	square angle-staff, plugged
9	6	,,	deal drawer runners
34	0	,,	groove
48	9	,,	ditto, and tongue
10	6	,,	1 in. nosing.
52	7	,,	ditto, skirting grounds, plugged
25	0	,,	ditto, picture grounds, ditto
4	6	,,	ditto, double beaded pinrail, 4½ in. wide
75	0	,,	ditto, architrave moulding, 2¼ in. ditto
60	6	,,	ditto, ditto, 3½ in. ditto
76	6	,,	1¼ in. ditto, ditto
6	6	,,	ditto, ditto, circular
20	0	,,	ditto, mitred border
9	6	,,	moulding, 4 inches girt
2	6	,,	ditto, ditto, circular
12	0	,,	2½ in. deal wrought and framed legs
15	6	,,	ditto, turned newells
13	0	,,	ditto, moulded handrail

We are compelled by want of space to terminate our ideal "Bill of Quantities" for joiner and ironmongery here at the conclusion of the articles which are measured by foot-run. On resuming the subject in our next lesson, we shall commence with such of the joiner's work as is taken by number.

TECHNICAL DRAWING.—LXXV.

DRAWING FOR BRICKLAYERS (*continued*).

THE example (Fig. 599) forming the subject of the present lesson is the ground-floor plan of a small villa built of malms, with stone dressings. The plan is drawn to the scale of ⅛-inch to the foot, the exterior walls being a brick and a half thick, whilst the interior ones are one brick thick.

On entering the house, we have first the hall, on the right-hand side of which is the dining-room, and on the left the drawing-room.

As the villa stands alone, or as it is termed "detached," these rooms which are at the corners have two windows each, by which means different views of the surrounding country are obtained, and the cheerful aspects are increased.

The front window in the drawing-room is a "bay" 7′ 6″ wide, and 3′ 3″ deep. This feature adds to the size of the room; makes a very pleasant recess, and is a great improvement to the elevation of the villa.

The side window may be made to open like a pair of folding-doors into a conservatory or garden; these are called "French casements."

On the same side of the hall, and immediately at the back of the drawing-room, is another smaller room, the library or study; this is also lighted by a window overlooking the garden, and thus the room is light, airy, and cheerful; but still it is from its situation removed from interruption. By placing a door where marked in the wall, access may be obtained from the drawing-room to the library, which being opened when occasion may require, will give increased accommodation.

Passing along the entrance-hall under the landing, we have a water-closet on the left, and a door leading to a little back lobby, on the other side of which is the back door leading to the kitchen garden or drying ground.

On the right-hand side of this lobby is the kitchen, beyond which is the scullery, and on the left side is the pantry and store-room.

It will be evident that when the door at A is closed, all communication between the kitchen and scullery, and the dining-room, library, and drawing-room is effectually cut off, thus preventing the annoyance, so often experienced in houses of this class, of the odour arising either from kitchen or scullery spreading into the other apartments. This door should be made self-closing by means of a spring, and could, of course, be hooked back when required.

By this disposition of the front and back doors a thorough current of fresh air passes from one side of the house to the other. They should therefore be opened together at certain periods every day, and if the windows of the rooms be opened at the same time, the whole mass of air in them will be purified. This does not apply to the ground floor only, but to the whole house.

Many persons are under the impression that a house is properly and efficiently cleansed by sweeping and dusting. There cannot be a greater mistake. Very much of the dust so disturbed rises and floats in the air, which is further vitiated by the breathing of the inhabitants, gas, etc. It is absolutely necessary not only that the floors and stairs, but the *whole atmosphere* of a house should be swept; and therefore, in the morning especially, the doors below should be opened, and the fresh air allowed to pass completely through the house, the bedroom doors and skylight having been previously opened. The impure air will thus be changed, and the comfort, cheerfulness, and health of all in the house will be improved accordingly.

The scullery or washhouse is placed adjoining to the kitchen, but may, of course, be separated from it by closing the door. The external door of the scullery opens directly on to the yard or drying-ground.

The pantry, which has already been mentioned, is for convenience placed opposite to the kitchen, so as to be as far as possible removed from the influence of the continuous fires. The floor is tiled, and slate and wooden shelves are affixed to the walls. Especial attention should be paid to the ventilation of the pantry. There should be an aperture at the bottom of the door covered with perforated zinc, and the upper panes of the windows should be replaced by pierced glass, or some other form of ventilation.

A door from the pantry leads to the store-room. The floor of

this room is boarded, and it is furnished with commodious cupboards. A small fireplace is also provided to prevent damp, and for the occasional airing of the room. A small aperture in the bottom of the door, covered with perforated zinc, will, together with the open chimney, keep the room ventilated, and more air may, of course, be obtained by opening the window. In the basement are coal, beer, and wine cellars, and other domestic offices, which would be shown in the basement plan.

This plan should be drawn on the lower part of the sheet of paper, so that the elevation may be projected from it. Great care must be taken in working accurately to the scale, and in preserving the rectangular forms of the rooms. This is best done by using the set-square against the T-square, as already explained.

Fig. 600 is the front elevation of the villa. The general widths of the various parts will be obtained by projection from the plan, whilst the heights and details are to be obtained from the examples. It is not usual in elevations to delineate the separate bricks, a few lines being merely drawn to indicate the character of the material of which the house is built. The same remark applies to the slates of the roof. All architectural drawings should be inked and coloured.

TO COLOUR ARCHITECTURAL DRAWINGS.

Assuming that the plan and elevation have been carefully inked, the next process is that of colouring them.

The plan of the walls, representing brickwork, is generally coloured with lake; but many draughtsmen prefer a full black, which really shows the exact forms to great advantage, especially in large drawings intended for exhibition.

For colouring elevations, crimson lake mixed with burnt sienna or Venetian red gives a nice tone of colour for *red* brickwork; very pale yellow ochre is generally used for malms; and the same, or pale sepia, for stonework used for the dressings. Granite is represented by pale Indian ink, and red sandstone by light red.

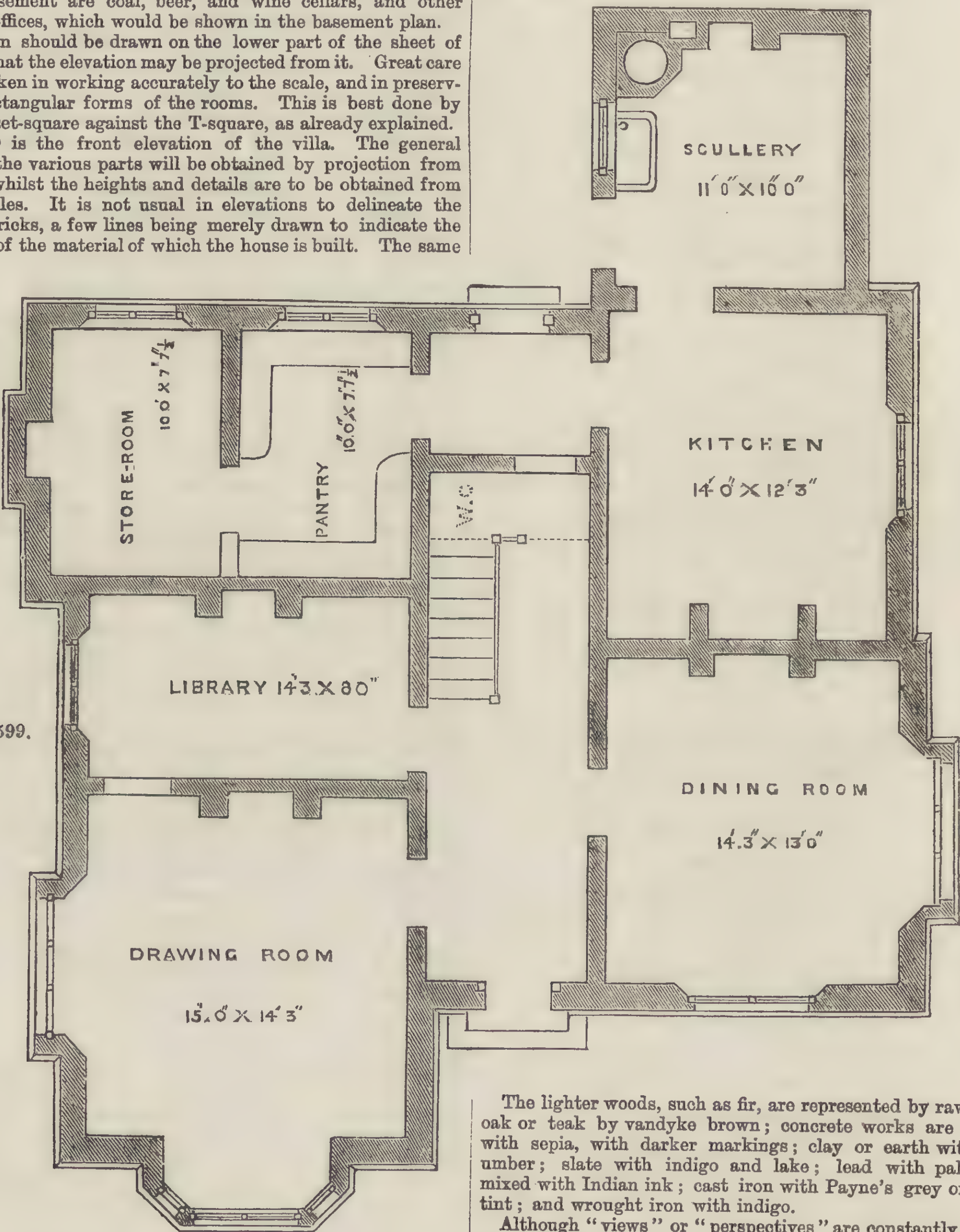


Fig. 599.

The lighter woods, such as fir, are represented by raw sienna; oak or teak by vandyke brown; concrete works are coloured with sepia, with darker markings; clay or earth with burnt umber; slate with indigo and lake; lead with pale indigo mixed with Indian ink; cast iron with Payne's grey or neutral tint; and wrought iron with indigo.

Although "views" or "perspectives" are constantly made by the architect, they are intended to show how the building will look when finished; but they are not in any way concerned in the construction. The drawings to which we have alluded are those required, and our instructions as to colouring will therefore in the present instance be limited to flat tinting, not by any means extending to "drawings in water-colours."

This must not be construed into any desire on our part to check the laudable ambition of the student; we merely wish to advise him to limit his efforts at first to that which is absolutely necessary; and this foundation once laid, a superstructure of the noblest character may with safety be raised on it.

We wish to impress on the student that no amount of shading or colouring, however well done, will improve a bad drawing; whilst a good outline will mostly represent the object without either one or the other; and therefore, although the learner is advised to spread flat tints over his earliest drawings so as to represent material only, by this means carrying on a course of improvement in both branches simultaneously, he is warned against spending time on making highly-finished picture views until he has mastered the principles of architectural construction, of architectural drawing and flat colouring, and until he shall have acquired such a knowledge of perspective as may ensure the correctness of the outline.

The colour for laying a flat tint must be very thin; it is very easy to spread another wash over it when dry, if not found dark enough, but if too dark it is not so easily lightened; in fact, this is seldom satisfactorily accomplished.

In mixing two colours, so as to produce a third, as in the case of lake and burnt sienna mentioned above, rub the colours in separate compartments of the slab, or at different parts of the palette, leaving a space between them, in which the colours are to be mixed with the brush. Never rub one cake in any other colour previously mixed; by this plan the end of the cake becomes stained, and consequently the purity of the colour afterwards rubbed from it will be impaired.

Use a large brush in preference to a small one wherever possible, especially in laying flat tints, which are liable to become streaky when coloured with a small brush.

The whole surface which is to receive a flat wash should be covered as rapidly as possible, but care must be taken that the brush does not pass over the outlines. Should this, however, occur, it is best to take up the colour covering the whole surface with blotting-paper, and allow the paper to dry; then repeat the outline, and colour as before, but with more care; the part at which the outline had been overstepped will then be visible, but of course not so dark as the rest. Now moisten this with a brush containing colour, and allow it to soak in for a moment, then take up the water from the surface with blotting-paper. Cover the part of the drawing which has been correctly coloured with a strip of paper, holding it tightly against the outline; rub the part coloured accidentally with a piece of clean india-rubber, and by this means it will in most cases be removed. If possible avoid scraping with a penknife or eraser, as the paper thus becomes roughened, and catches the dust more easily than if the above method has been pursued.

After the colour has been spread it should not be touched again whilst wet. If it should require any retouching, let this be done when it has dried; it will generally be made worse by any attempt to remedy it by stirring about in the wet colour, and, further, the surface of the paper will become roughened.

Fig. 600.

In order to obtain the necessary practice in laying flat washes, which is of great importance in architectural drawing, the student is advised to draw several squares, circles, rectangles, triangles, etc., of different sizes; to commence by colouring the smallest, and gradually proceeding to those of increased size. The brush should be held as upright as possible, so that the point and not the side may be used.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIV.—CHARLES SPALDING.

BY JAMES GRANT.

THIS ill-fated inventor of many improvements on the old diving-bell was born at Edinburgh, about the year 1735. He commenced life as a shop-lad; his parents were in humble circum-

stances; but being steady, thrifty, and industrious, he ultimately succeeded in establishing himself in an extensive business as a confectioner and sugar-refiner. All his leisure hours were turned to the study of mechanics, and among many other things to which he gave his attention was the diving-bell, which no man in Britain had ever attempted to use, since the days of Dr. Halley.

Spalding being a man of a brave and intrepid spirit, and inspired also by a keen curiosity to inspect the wonders of nature, made several attempts to descend into deep water with the bell, and ultimately succeeded, so that he could remain under the surface for a considerable time. This led him to consider attentively the general construction of the bell, and seek to render it more useful and safe.

The diving-bell is most conveniently made in the form of a truncated cone, the smaller end being closed and the larger opened. It is to be poised with lead, and so suspended, that it may sink full with air, and with its open face downward, and as nearly as may be in a situation perfectly parallel to the horizon, while the diver, sitting under it, sinks down with the included air to the depth required. If the cavity contained a ton of water, it would hold air sufficient for a man, for a full hour, at six fathoms deep; but the lower he went, the included air contracted, according to the pressure of the water, into a compass so small, as to become heated and unfit for respiration, so that there was a necessity for it being drawn, to recruit it, and then generally the diver was almost covered with water. To obviate these difficulties, Dr. Halley had contrived an apparatus which not only recruited the air from time to time, but also kept the water wholly out of the machine, which was so loaded with lead, that it would descend in a perpendicular direction, but no other. In the top was a window to admit light, and a cock to let out the hot air, while the fresh was supplied from two barrels that rose and fell like two buckets in a well; while by an additional contrivance, the diver could quit the bell and walk some distance, the air being constantly conveyed to him in a machine by small flexible pipes.

Such was the diving-bell as left by Dr. Halley, who died in 1741, and in it Spalding discovered several dangerous tendencies, the two chief being:—1st. The sinking or raising of the bell depended on the people who were at the surface of the water, as the bell when under it attained a very considerable weight, and thus to raise it required not only a great deal of labour, but there was a possibility of the suspension ropes breaking, and every person within it perishing. 2nd. As there are in many parts of the sea rocks, the form of which cannot be perceived from above, there was a chance that some of their ragged projections might arrest the edge of the bell in its descent, and thus overset it, before the divers could give any signal to those above, an event certain to be attended by the total destruction of all within it, as before trial it is impossible to know what the bottom of the sea may be like.

To obviate these defects and dangers was the first task of Spalding, and this object he attained in the following manner:—On iron hooks he suspended leaden weights to keep the mouth of the bell *always* parallel to the surface of the water, whether the machine taken is lighter or heavier than an equal bulk of water. By these weights alone, however, the bell would not sink, so he added another to be raised or lowered at pleasure, by a rope passing over a pulley and fastened to the sides. This he called "the balance weight," as it hung considerably below the mouth of the bell. It served also as an anchor, to keep the bell at any particular depth which the divers may deem necessary, or by pulling it quite up the descent may be continued to the bottom. By another ingenious contrivance, too long for description here, Spalding rendered it possible for the divers below to be independent of those above, and to raise the bell with all its weights to the surface, or to stop its descent at any depth they chose. For the wooden seats used by Dr. Halley, he substituted ropes, suspended by hooks, with two side windows of strong glass for the admission of light, and he maintained that one air-barrel, capable of containing thirty gallons, was sufficient for an ordinary machine. Steele, Rowe, and James have made considerable improvements since, even on Spalding's bell, but such was the nature of the machine in which he made several descents, and which finally, towards the close of the last century, attracted the attention of the government.

He became so proficient as a diver that he could remain in his bell for several hours at the depth of fourteen fathoms, and the *Edinburgh Advertiser*, for 1783, records that a lady and a gentleman named Watson went down with him in Leith Roads, "and remained at the bottom of the sea for half an hour."

A ship from London, bound for Leith, on board of which Spalding had much goods consigned to him, having been cast away, he made a proposal to the owners of the general cargo, "that if they would bear a share in the general expenses of his journey to where the wreck lay, he would make every effort in his power for the recovery of their joint property." On their declining, Spalding at his own risk visited the wreck, and though he recovered little or nothing of his own consignment, being chiefly sugar and other perishable commodities, he brought up much that belonged to others, which no law could wrest from him.

Few events at the time created a more profound sensation in Britain than the sinking of the *Royal George*, a line-of-battle-ship of 108 guns, which turned over when undergoing what the sailors term "a Parliament heel," in Portsmouth harbour, when the venerable Admiral Kempenfeldt (then in his seventieth year), and upwards of 400 officers, seamen, and marines, with nearly 200 women, perished, on the 29th of August, 1782. Immediately upon this, the Admiralty and Navy Boards sent to Edinburgh for Spalding, to have the wreck inspected, and, if possible, raised wholly or in part. He engaged to do this on condition "that he was to have one-third of all the property he could raise belonging to the *Royal George*."

To this the Lords of the Admiralty agreed, and he paid the wreck a series of visits in his diving-bell, and brought up seventeen brass guns, several of iron, and other stores to the value of £1,000, the whole being estimated at thrice that sum. For this, however, he only received £400, half of which went for his expenses. He reported "that the ship lay in very bad ground, surrounded by tides, and very deep."

The newspapers of the time record, that "Mr. Spalding being down, one very clear day alongside the *Royal George*, perceived every object on board as distinctly as above water, and beheld one of the most tremendous and shocking spectacles that the human mind can form. Great numbers of the dead bodies in various attitudes; some clinging to the carriages of the guns; others crushed with the guns above them; and when it is recollected what visages they must have in that state of putrefaction, no imagination can paint it without the utmost horror. But what sensations must he have felt when viewing it in reality! Through the cabin-windows he could see the body of the admiral floating about."

On the cold season setting in, he returned to Edinburgh in the October of 1782, pledging himself to resume operations when the weather permitted. In the meantime, he was sent for by the underwriters of the *Belgioso*, an Imperial East Indiaman, which had been wrecked some time before in Dublin Bay when outward bound from Liverpool. Every soul on board perished with her. Her cargo was valued at £150,000, of which £30,000 were in silver and lead, and their agreement was, "that he should have one-fourth of the silver and lead, and one-half the rest of the cargo; and though he should not recover an article, they were to defray his expenses from the day he left Edinburgh to the day he returned." As she lay in ten fathoms water, and six miles from the shore, not amid quicksands, with her masts visible at ebb, there was every prospect of his realising the liberal offers of the Liverpool underwriters prior to resuming his labours on the *Royal George*, the wreck of which he proposed to blow up, as has since been done, by gunpowder. At this time he was also in correspondence with Commodore Elliot, the Governor of Gibraltar, who wished him to raise 400 brass cannon, that were sunk in the Bay by the Spaniards when they abandoned the siege of that fortress on the famous 13th of September, 1782.

In May, 1783, he was at Dublin, and anchored his small brig in the Bay, with his diving-bell on board. On this occasion he was accompanied by a friend, Mr. Ebenezer Watson, also of Edinburgh, and together they paid four visits of inspection to the wreck of the great Indiaman, which lay near a place called the Kishes.

The fourth visit was paid by them on the 3rd of June, when the water was seven fathoms deep, and they were below it exactly an hour and a quarter. During the first hour the signals had

been properly attended to, and three supplies of fresh air were sent down; but it is supposed that unhappily, by some blunder of those above, the last barrel failed to reach them, and thus brought on almost instant suffocation. It must have been so immediate as to have prevented Spalding from adopting the mode of preservation invented by himself—viz., that of cutting away the weight that hung from the centre of the bell, by which means it must have instantly risen to the surface.

On drawing up the bell, Spalding and his young friend Watson were both found dead, the former resting on the breast of the latter, who was sitting erect in the slung seat. No medical man being at hand, when the brig ran into Dublin harbour all attempts at recovery were futile. At the inquest, the captain asserted that the signal ropes must have become entangled below water. By this catastrophe Spalding's widow and seven children were left in penury, and Watson's aged mother. The event made some sensation in Dublin, where Spalding and Watson were interred together in the churchyard of St. Mark. They were borne shoulder-high by the crew of his brig, and were preceded by the marine boys singing hymns. Many of the most influential citizens attended the funeral, and all the vessels in the harbour and bay had their flags half-hoisted as a tribute to Spalding's memory.

SHIP-BUILDING.—XVI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE DECKS OF SHIPS.

Decks were originally constructed in ships solely for purposes of convenience and accommodation; now they are recognised not only as valuable platforms, but also as important contributories to the structural strength. In some of the earlier papers attention was directed to this fact, and the usefulness of decks in assisting to prevent changes of form in either the longitudinal or the transverse direction was illustrated. Consequently it is unnecessary here to discuss the subject further; but taking for granted the importance attaching to the proper construction of decks, and their connection with the other parts of the structure, we will attempt to show how in practice these special requirements are met. As in other cases, our treatment must necessarily be brief, and only the principal features of the various arrangements can be described.

The surface of a deck is curved both longitudinally and transversely. The longitudinal curvature is termed "sheer," and the transverse curvature "round up." The latter is mainly given in order to facilitate the flow of water to the sides of the ship, where "scuppers" are formed to permit it to pass overboard. Sheer is given to the decks mainly for the sake of graceful appearance in the upper boundary lines of gunwales and topsides; the foremost and aftermost ends of the deck being usually higher than the amidship part. It is very commonly supposed that a loss of strength is caused by giving sheer to the decks instead of having them straight; but this is not true, provided the decks are so strongly connected with the sides of the ship, as to prevent any change in their relative positions; and there is no practical difficulty in securing the strength required for the purpose. Some ship-builders have even gone so far as to give the decks longitudinal curvature in the reverse sense from that usually given, thinking that the *arched* form thus obtained would be most valuable in resisting hogging strains; but in doing so they have overlooked the facts, that sagging as well as hogging strains have to be resisted, that change in the longitudinal form of the ship must affect the sides as well as the decks, and that the great aim of the builder should be to secure joint action and mutual support between the sides and decks.

Structurally considered, decks may be said to consist of the "flat" and the "framing." Under the former heading may be included the planking forming the platform upon which the various fittings are constructed, and the different weights directly rest, together with any iron plating that may be fitted beneath the planking. As framing may be reckoned those pieces which support the flat, just as the frames support the skin of a ship, these pieces are named beams, half-beams, carlings, etc., and closely associated with them are other pieces named "shelfs" and "waterways." The support of the decks does not wholly depend upon the strength of their framing, but is largely aided by pillars fitted between decks and in the hold. In building a ship the decks are first framed, and the flats are laid afterwards; so that the most natural course is to give precedence to the framing in the following remarks.

In nearly all ships the deck-framing is placed transversely. A few iron ships have been constructed by Mr. Taylorson with diagonal deck-framing, associated with other diagonal arrangements; and others built on Mr. Scott Russell's longitudinal system have had their decks supported by longitudinal girders; but these exceptional cases are so few as to merit no detailed description. The almost universal rule is to place the transverse deck-beams at moderate distances apart, and to make them stretch from side to side, strongly connecting their ends with the framing and skin of the ship. The spacing of the beams depends largely upon the positions of the hatchways and other openings in the decks, in wake of which the beams cannot, of course, be continuous from side to side; at such places short transverse pieces or half-beams are fitted instead. The outer ends of these half-beams are secured to the ship's side, and their inner ends rest upon longitudinal pieces of the deck-framing, termed "carlings," fitted between the beams. In some cases half-beams are fitted at other parts of decks, so that the spacing of the beams may be increased and the weight of the deck-framing reduced; but this practice is almost entirely confined to wood ships. These three classes of pieces—beams, half-beams, and carlings—form the deck-framing in most modern ships, whether wood, iron, or composite; and although in older wood vessels other modes of framing were employed, we cannot here attempt to describe them.

The beams of most wood ships consist of solid timbers of nearly uniform depth and of rectangular cross section (see 3, Fig. 5, Vol. III., p. 29). They commonly have to be made up in length by two or three pieces, which are joined by scarfs, either plain or hooked (see Fig. 8, Vol. III., p. 30). Their spacing, from centre to centre, varies from 3 to 4 or 4½ feet when there are no half-beams; and when half-beams are fitted in order to lighten the deck-framing without leaving the flat unsupported, the spacing is sometimes made as much as 5 or 6 feet. In determining the actual positions of the beams regard is had, as was said above, mainly to the positions of hatchways; but other considerations connected with deck fittings, special weights requiring support, possibility of fitting pillars, etc. etc., also have great influence. Half-beams and carlings are of similar sectional forms to the beams, but usually of less dimensions. Iron beams are sometimes used in wood ships, and in the next paper an example of such an arrangement will be given.

Wood beams were commonly used in the earlier iron ships, but they soon gave place to iron. The advantages of the flanged form possible with iron beams, as regards strength and lightness, have already been illustrated; and in 1 and 2, Fig. 5, two sectional forms for iron beams are shown. Section 1 has not been much used, and could not be rolled in one piece until quite recently; but we believe beams of considerable size on this pattern can now be rolled. The old plan of making it was to roll half the web and either the upper or lower flanges in one T-shaped piece, afterwards welding the two parts (at the bottom of the T) throughout the length of the beam. Section 2 is known as a "made" beam, and it has been largely employed. Besides these, many other sectional forms have been used, some of which will be illustrated hereafter. One of the simplest is the simple angle-iron form, but this is deficient in having only an upper and no lower flange. To supply this want a "reversed" angle-iron has sometimes been riveted to the simple angle-iron beam, and so a section like that of the frame of an iron ship (see Fig. 20, Vol. III., p. 150) has been obtained. Another plan has been to roll the angle-iron with a bulb at the lower part of the flange placed vertically; T-iron beams have also been used. Besides these we will only mention here the so-called "box-beams," sometimes used where great strength is required. They are of rectangular section, the sides, top, and bottom consisting of comparatively thin plates connected together by angle-irons fitted at the corners of the rectangular section. These beams are nothing less than small tubular girders, and they can be almost as readily made as the T-shaped beams similar to 2 in Fig. 5, Vol. III., page 29.

We have already remarked that in an iron beam there is no necessity for such elaborate connections of the pieces as there is in a wood beam. Usually the manufacturer sends the beams to

the iron ship-builder in such a state, that their ends have only to be cut off to the exact length, and the necessary holes drilled or punched, before the beams are put in place. In cases where made-beams are used the builder has to prepare them himself, but the operation is very simple. The plates forming the web may, in a large ship, be in two or three lengths, which are joined by welding; and a similar operation suffices to procure the necessary lengths of the angle-irons. Care is taken to make the welds of the plates and angle-irons forming a beam give shift to one another, in order that any specially weak section may be avoided; and in many cases, in disposing these butts, regard is had also to the positions of the similar butts on neighbouring beams. Much interest attaches to many of the operations connected with the manufacture of iron beams, but space forbids us to enlarge thereon further than in connection with some of the more common methods of forming the "knees."

Figs. 52 and 53 will aid our description of these operations, and also enable us to complete our remarks on the sectional forms of beams. In the former sketch the beam is made up of a bulb-plate with double angle-irons on the upper edge; this is a very common sectional form in iron and composite merchant ships, and is both cheap and efficient. The bulb-plate is rolled in one piece, and afterwards combined with the angle-irons. The section in Fig. 53 is generally known as the "Butterley beam," having been first made by the Butterley Iron Company. It was formerly always made in two pieces, which were afterwards welded together (by a patented process) along a line near the centre of the depth or the "neutral axis" of the beam. Now beams of considerable size and of similar sectional form can be rolled in one, and the expense and labour of welding saved; but the welding process is, we believe, still necessary with the largest beams, such as are used in our iron-clad ships. The advantages gained in having finished beams turned out from the rolls, instead of having to combine the separate parts, are too obvious to need discussion; and there is every probability that the iron manufacturers will be able eventually to meet the ship-builder's requirements in this respect.

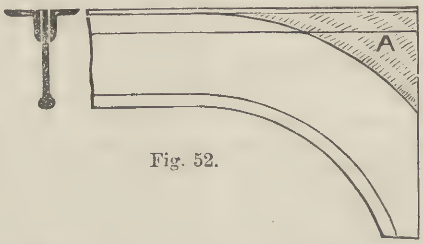


Fig. 52.

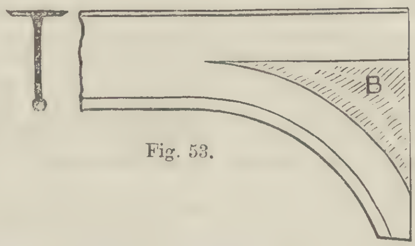


Fig. 53.

From these two sketches the outline of the form usually given to iron beam-knees will be seen, and hereafter the advantages gained thereby will be understood. The extreme depth of the knee is usually not less than $2\frac{1}{2}$ times the depth of the beam away from the knee. In Fig. 52 the desired form of knee is obtained by making the beam-end hot (before the angle-irons are riveted to the upper edge), and then bending the bulb-plate to the curve required for the under part of the knee; after which the piece of plate marked A, and dotted across, is welded on to form the upper corner. In Fig. 53 the plan followed is different. If the beam is formed of two pieces welded along the neutral axis, the welding is not performed for some two feet or so from the end; or if the beam is rolled in one piece the web is cut or split for an equal length, in order to separate the upper and lower parts. The beam-end is then heated, and the lower part turned down to the required curve to form the beam-knee; after which a plate marked B, and dotted across, is welded in to fill the space and complete the beam-arm. Sometimes the plate B does not entirely fill the space, but a triangular hole is left at the inner part. An example of this will be given hereafter. Care is, of course, required in welding plates (such as A and B) to the beam-web; and the operation takes some time, but when complete it makes very neat work.

I-shaped "made" beams usually have knees of similar shape to those we have just described, the web-plate being increased in depth for the purpose at the beam-end, and the angle-irons on the lower edge being bent to the curve of the lower edge of the knee. One of the best methods of forming such knees is to cut them out of a solid plate of sufficient breadth to allow two knees to be formed, and then by properly "lining" them out on the plate no great waste of material is involved. The knees, or "beam-arms" so formed, would extend in for 4 or 5 feet from the ship's side, and there be welded to the web-plate. It may occur to the reader that a plan similar to that in Fig. 52 might be applied here also, and this is the case when the beams are not of considerable depth; but as made-beams are mostly used where great strength is needed, there would be considerable difficulty in bending the deep web-plates to the curve required, and it is not usually attempted. Sometimes, to avoid the cost of cutting out the plate-knees, pieces of plate are either welded or riveted to the lower edge of the web-plate, in order to give the desired depth and form; and sometimes, instead of forming knees at all, the beams are continued of uniform depth quite out to the ship's side, and other means are adopted for securing their ends.

Half-beams in iron ships are usually of the same form and dimensions as beams, and have similar knees on their outer ends. The inner ends are simply secured to longitudinal carlings by short pieces of angle-iron, and the carlings themselves are similarly attached to the beams between which they are fitted. It is not usual to fit half-beams except in cases where some necessary arrangement of hatchways or deck-fittings prevents the beams from being made continuous from side to side. Almost without exception, the beams and half-beams are stationed at frames in iron ships, and their spacing consequently depends greatly upon the frame-space. In ordinary iron ships on most of the decks the beams occur at alternate frames, and are from $3\frac{1}{2}$ to 4 feet apart. In iron-clad ships the deck-beams are ordinarily spaced 4 feet apart; but in some cases where it has been desired to make the deck exceptionally strong, and very thick plating has been fitted, the beams have been only 2 feet apart. Such cases, however, must be regarded rather as having relation to necessities of defence, than of structural strength in the ordinary sense. The decks, in fact, are nothing less than targets strongly plated, and requiring to be strongly framed in order that the plating may be made as efficient as possible against the oblique or vertical impact of heavy projectiles.

Deck-beams are required to act not only as supports to the decks, but also as struts and ties keeping the two sides of the ship at a fixed distance apart, and to assist the framing in resisting any alteration in the form of transverse sections. The sectional forms of iron beams are practically regulated by the consideration of the strains brought upon them when acting simply as girders supporting the decks and the weights placed thereon. And when it is remembered that their strength as struts against compressive strains is very largely increased by their connection with the deck-flat, it will appear that this practical rule rests on a sound foundation. It is obviously fair to consider that with each beam we may associate, as a strong top flange, a portion of the deck-flat on each side of it extending to the middle of the beam-space. Supposing this to be true, and assuming the beam to be subjected to compressive strains tending to make it buckle, we see how great is the assistance it receives from the deck-flat to which it is fastened; and these are the strains to which a slight iron beam is most liable to yield when unstiffened. Direct tensile strains it can resist much better, and to enable its strength to be thoroughly developed it is only necessary to rivet it strongly to the frames. With wood beams there is no choice of any sectional form except the rectangular; and there is, of course, practically no danger of such beams failing under compressive strains, while the care exercised in scarfing the various pieces secures their efficient action as ties against tensile strains, provided their ends be securely fastened to the ship's sides.

Experience proves, however, that the greatest danger of change in transverse form arises from those strains which tend to produce alterations in the angle between the beam-end and the ship's side. The causes and mode of action of such strains have already been described; and in the next paper we shall try to illustrate the means employed to resist their action.

PATENTS AND PATENT LAW.—I.

By A Barrister.

UNPATENTED INVENTIONS.

In commencing the treatment of this interesting subject we must caution the reader that if he desires to make our information permanently useful he must carefully watch the proceedings of Parliament, as changes affecting the practice at least relating to patents are imminent. There is indeed a difference of opinion as to the advisability of preserving any monopoly, many persons whose judgment is entitled to weight being in favour of absolute free trade in ideas. At present the law rests upon a statute of James I., to which we shall presently allude—a statute which abolished monopolies generally, but expressly retained that which confers protection upon inventors whose discoveries relate to manufactures. That the law has remained for so long the same in principle is much in its favour; and it is indisputable that if our existing system be judiciously amended, the advantage to art and science will be as great as the original abuses of monopolies were enormous.

The most material question which we have to consider in the first place is the position of an individual who conceives a novelty in relation to matters covered by the term "manufactures," and who does not at once proceed to patent it. Has he any protection at all at common law, that is, as distinguished from statute law? M. Renouard, the author of an elaborate French work on patents, discusses the question whether an inventor has, by the principles of universal equity, an exclusive right to his invention; and an eminent American writer, Mr. Phillips, says that M. Renouard "very satisfactorily establishes the conclusion to which every mind is constrained to yield assent, that no such natural right exists." "Indeed," says the writer last cited, "there is no plausible ground whatever on which to rest such a right, since the fact of one person being the first inventor or discoverer affords no pretence for disfranchising others of the right, in their turn, of making use of the discovery." The only condition upon which an inventor can keep his invention to himself is that of secresy. It is the same with regard to literary productions as with mechanical inventions. The great American Chancellor, Kent, observes, "As long as these are kept within the possession of the author, he has the same right to the exclusive enjoyment of them as of any other species of personal property; for they have proprietary marks, and are distinguishable property. But when they are circulated abroad, and published with the author's consent, they become common property, and subject to the free use of the community." After many decisions of the courts, Lord Cottenham recognised as the established doctrine, that the property of an author or composer of any work, whether of literature, art, or science, in such work, unpublished and kept for his use and pleasure, cannot be disputed. And he added that if such right and property exist in the author of such works, it must so exist exclusively of all other persons. Upon this arises a very nice question as to what acts of an author or inventor will deprive him of his right—a question which has been frequently discussed on many different states of facts. And this is most important to inventors, inasmuch as by an indiscretion they may lose their right to a patent.

An instance of the danger of losing the benefit of his invention to which an inventor is liable is given in the work of Mr. Phillips already referred to. A person had invented an improvement upon spectacles, and as his patent was in a state of forwardness he had not been sufficiently cautious in keeping the invention to himself, so that another person in the same trade had acquired a knowledge of it, and hastily got a pair made upon the same construction, and exposed them in his window. Fortunately, however, the inventor happened to pass the shop, and seeing them, employed a friend to go and purchase them, in which he succeeded, and his patent passed the Great Seal the next day, before there was time to get any more made. It is difficult to see, however, that this patent could have been held good. There was knowledge of the secret, an actual making, and a public sale by a person who was not the patentee. All the world does not think alike on this subject of publication. France has adopted the English doctrine, but the United States law is satisfied if the invention was new at the time that it was made; and it is considered that the inventor is rather benefited by making known his invention as soon as he has reduced it to practice, because he supplies himself with proof of the date of the invention.

In the beginning of the present century a case was decided in the Court of Errors in France which well illustrates the rule which prevails in that country and in England. The inventors of a carding machine had disclosed their invention to the municipal administration of Orleans, who, at their request, had tested its utility by a public inspection and experiment, of which they had given a formal certificate to the inventors. The inventors, moreover, had voluntarily permitted a manufacturer to use their machine to card with. It was adjudged that in thus giving publicity to their invention they had voluntarily made it public property, and consequently, that the patent subsequently obtained by them, though in other respects legal, was invalid. The inventors protested that they did not intend to make their invention public, or to part with their rights, which we can well understand. But the only question in such a case must be, whether publicity has been given to the invention, from whatever cause; for it is the publicity which gives the public the right, and consequently deprives the inventors of their privilege.

It is desirable to fix with as much precision as possible the kind of proceeding on the part of an inventor which will prevent him from subsequently obtaining a patent. This was discussed in the great case of Betts' patent for metallic capsules, where it was said that a person named Dobbs had made the process public before the date of Betts' patent. Lord Chancellor Chelmsford considered carefully the "nature and extent of the information published to the world, which will be sufficient to disprove the novelty of a subsequent invention," that is to say, which (having regard to our present purpose) would disentitle an inventor to a patent at all. In one of the cases referred to, Lord Westbury answered the question thus: "There is not, I think, any other general answer that can be given to the question than this, that the information as to the alleged invention given by the prior publication must, for the purposes of practical utility, be equal to that given by the subsequent patent. If specific details are necessary for the practical working and real utility of the alleged invention, they must be found substantially in the prior publication." This was not entirely adopted by the Court of Queen's Bench dealing with the same patent; that court considering that whilst the earlier specification might insufficiently describe the process, so as to make the specification bad, it yet might disclose enough to show that what was claimed on the patentee's specification was not wholly new. And Lord Chelmsford expressed his entire concurrence with the view put forward by Mr. Justice Williams, "that the publication of a *notion* that a certain useful art may be discovered, without any information or means of discovery, cannot preclude a subsequent inventor of those means from taking out a patent for the entire art." A publication of a description of a machine in a book is enough to deprive the inventor of his property in it. "If," Lord Lyndhurst said in a case, "the machine is published in a book, distinctly and clearly described, corresponding with the description in the specification of the patent—though it has never been actually worked—is not that an answer to the patent?"

Then, in addition to publication, there is another process by which a new idea may be lost to its originator, and that is by public use. Mr. Justice Erle told a jury that manufacturing according to the subsequent patentee's invention, and sale "commercially" of the article so manufactured, would be a "public use." To support a public use a learned Vice-Chancellor required the evidence of "somebody who was an habitual purchaser." The same judge said "a manufacture of an unsaleable article will not be an anticipation of a patent which will produce a different, and a saleable, and a merchantable article." A doubt may well occur to the reader as to what is an unsaleable article. Lord Chelmsford supposes the words to mean a "worthless article;" "for," he said, "an article which is capable of some useful application may, from circumstances, be unsaleable at a particular time, and yet, if manufactured not for experiment, but in the way of trade, may prevent another patent having a claim to novelty." He further held that to establish a public use it is not even necessary that the patented article should have been previously manufactured for sale. As an example, a lock on a new principle was put on a gate adjoining a highway, and that was said to be a public use, so as to

defeat a subsequent patent. A late Baron of the Exchequer defined "public use" to mean "a use in public so as to come to the knowledge of others than the inventor, as contradistinguished from the use of it by himself in his chamber." Lord Abinger defined it thus: "the public use and exercise of an invention means a use of an invention *in* public, not *by* the public."

This reference to authoritative opinion on the subject we are dealing with makes it very clear, and it is only necessary to state what rules have been established as regards literary and artistic property, the law of copyright being distinctly on all-fours with the law of patents. These rules have been well summed up thus:—That the right of property of the author or composer of any works of literature, art, or science, in such works, so long as they remain unpublished, is so complete and absolute, that no one else, without his permission, may publish even a list or descriptive catalogue of them; that the circulation amongst a few private friends of impressions of etchings, not otherwise published, is not such a publication of them as disentitles the owner to the protection of this right, and that this right is but part of the general common law right of property. The question of publication is, of course, quite as important respecting this description of property as in the case of mechanical inventions; and in addition to the case of the etchings referred to above, we will give a few examples of what amounts to a publication so as to divest the author of his right of property. We may premise that the thing itself must be published, not something resembling it, such as an abridgment. A public performance of a play does not deprive the author of his common law right of property in it. By sending letters to another the right of publishing them is not lost; nor does the mere gift of copies of an author's works to a few friends amount to an abandonment of his copyright before publication. Unpublished lectures, delivered under certain conditions, musical and dramatic compositions, engravings, maps, and charts, are protected by statute.

We hope we have placed the position of an inventor at common law so clearly before the reader that any *résumé* may be unnecessary. But with reference to what we have to say further on, we will re-state the simple principle thus:—An inventor may retain the exclusive property in his invention without a patent, so long as he does not allow it to become publicly known by description in a publication or use in public. In the case of literary or artistic creations there may be a public use without amounting to a publication so as to deprive the author of his property in his work.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXV.—HENRY CORT.

BY JAMES GRANT.

HENRY CORT, the founder of our iron aristocracy, was born at Lancaster in the year 1740. His father was by trade a builder and brickmaker. Of the early history of Henry Cort nothing is accurately known, but (according to a notice of him which appeared in the *Mechanics' Magazine*) he would seem to have raised himself by his own unaided efforts to a position of respectability. In his twenty-fifth year he was established as a navy agent in Surrey Street, Strand; and it was while managing business in that capacity that he seems first to have become aware of the inferiority of British iron, as compared with that which came from Russia and Sweden. The English nation could not carry on their manufactures without the foreign ore; hence their wrought iron was prohibited from all Government contracts, and their cast iron was too brittle for general use.

A supply of iron being required for the Royal Navy, first drew Henry Cort's attention to this state of matters in the iron trade, and he began a series of experiments with a view of improving the manufacture of the metal. What these experiments were, or how he achieved the results that he did, no one knows now. All that is known is that in the year 1775 he quitted his offices in Surrey Street, and took on lease certain premises at Fontley, near the seaport of Fareham, in Southampton, where he built a forge and iron-mill; and then he took into partnership a Mr. Samuel Jellicoe (son of the deputy-paymaster of seamens' wages), a measure that proved in the end a most unlucky one.

Henry Cort took up the art of manufacturing iron at the point where it had been left off by Dr. Roebuck in 1762, the Brothers Cranage in 1766, and others; and he succeeded so far with his new experiments at Fontley, that in 1783 and 1784 he published his patents. In his process he dispensed with a blast; but in that he had been anticipated by the Cranages, and in puddling by Peter Onions of the Merthyr Tydvil Works. Yet he introduced so many improvements of a new and original character, combined with the inventions of some of his predecessors, that in a few years he raised the iron manufacture to the highest state of prosperity—so true it was with Cort that "the man who will distance his competitors is he who masters his business, who preserves his integrity, who lives clearly and purely, who devotes his leisure to the acquisition of knowledge, who never gets in debt, who gains friends by deserving them, and who saves his money;" but, unfortunately for Cort, through his connection with Jellicoe he failed in the latter element of success.

So early as 1786 Lord Sheffield, of the Board of Trade, and a most distinguished writer on political economy, who died so lately as 1821, perceived the vast importance to the nation of Cort's improvements, and said in public:—

"If Mr. Cort's very ingenious and meritorious improvements in the art of making and working iron, the steam-engine of Boulton and Watt, and Lord Dundonald's discovery of making coke at half the present price, should *all succeed*, it is not asserting too much to say that the result will be more advantageous to Great Britain than the possession of the thirteen colonies of America, for it will give complete command of the iron-trade to this country, with all its vast advantages to navigation."

The peer he referred to as the discoverer of coke was the Scottish Earl of Dundonald, who, after serving in the cavalry, devoted a long life to scientific objects, chiefly with the view of benefiting the commercial and manufacturing interests of Scotland.

Cort states in his patents, that after great study and expense, "he had invented and brought to perfection a peculiar method and process of preparing, welding, and working various sorts of iron, and of reducing the same into uses by machinery: a furnace, and other apparatus adapted to the said process."

For anchors and similar iron-work, the fagots of piled iron were worked and welded into bars by rollers in lieu of forge-hammers; but it does not appear that there was any novelty in this use of rollers, as Cort refers to them in his specification as if already known. He had the merit of selecting and *combining* the best inventions of others, apparently, rather than of discovering much that was new.

An increased demand for iron was the result of all this, and hence the production of that manufacture, "which in the early part of the last century amounted to little more than 12,000 tons, about the middle of the century to 18,000, and at the time of Cort's patent to about 90,000 tons, was found in 1820 to have increased to 400,000 tons; and now the total quantity produced is upwards of *four millions* of tons of pig-iron yearly, or more than the entire production of all other European countries. There is little reason to doubt that this extraordinary development of the iron manufacture has been in a great measure due to Henry Cort; and it is said that at the present time (1863) there are not fewer than 8,200 of Cort's furnaces in operation in Great Britain alone."

Though the processes of Cort were discovered and adopted by others, the Lords of the Admiralty having, by persons appointed to test it, approved of his iron in particular, it was directed to be used alone in the navy for anchors and other iron-work, while numerous contracts for licences were entered into with Cort and his partner by the manufacturers of bar iron throughout the country. Cort now began to make arrangements for carrying on the manufacture of that metal on an enormous scale, and with that object obtained possession of a wharf at Gosport belonging to Adam Jellicoe, the father of his partner, when he succeeded in obtaining extensive Government orders for iron made after his patents, while licences were taken at royalties estimated to yield £27,500 to the owners of these patents.

Henry Cort seemed now on the high road to the realisation of

a princely fortune; "but there was a fatal canker at the root of this seeming prosperity, and in a few years the fabric which he had so laboriously raised crumbled into ruins; for, on the death of Adam Jellicoe, the father of Cort's partner, in August, 1789, defalcations were discovered in his public accounts to the extent of £39,676, and his books and papers were immediately taken possession of by the Government."

An examination proved that the debts due to Jellicoe senior amounted to £89,657, including the sum of £54,853 owing to him by the firm of Cort and Co., to which he had advanced money from time to time, to pursue experiments of an expensive character, securing himself, however, by a deed of agreement entitling him to one-half the stock and profits of all his contracts, and Cort subsequently assigned to him all his patent rights as collateral security. All this made the business connection a most unfortunate affair for him, as it was discovered that among the money advanced to the firm by Adam Jellicoe there was a sum of £27,500 entrusted to him for the pay of the officers and seamen of the Royal Navy! Embarrassments had fatally tempted him to make use of this money; and desperate attempts to set himself right only involved him more and more; the result preyed upon his health and shortened his life. On this discovery, the measures of the authorities were sharp and prompt.

"The body of Jellicoe was worth nothing to them, but they could secure the property in which he had fraudulently invested the public money entrusted to him. With this object the then Paymaster of the Navy proceeded to make an affidavit in the Exchequer that Henry Cort was indebted to His Majesty in the sum of £27,500 and upwards, in respect of moneys belonging to the public treasury, 'which Adam Jellicoe had at different times lent and advanced to the said Henry Cort, from whom the same now remains due and owing; and the deponent saith he verily believes that the said Henry Cort is much decayed in his credit and in very embarrassed circumstances; and therefore the deponent verily believes that the aforesaid debt so due and owing to His Majesty is in great danger of being lost if some more speedy means be not taken for the recovery than by the ordinary process of the Court.'"

The assignments which poor Cort had made of his patents were thus taken in security, while, most singular to say, Samuel Jellicoe, *the son of the defaulter*, was unjustly put in possession of the forges and mills at Fontley and Gosport, and continued to enjoy them, to the exclusion of Cort, for fourteen years.

It has been alleged that the simple process of demanding of the iron-masters who contracted with him their patent dues—amounting to £15,000 in 1789, to £15,000 in 1790, and to £25,000 in 1791—might have saved Cort from the irreparable ruin that fell upon him; but they were, however, prepared to dispute his rights at law, as they had been at variance with him.

"Mr. Cort has been most illiberally treated by the trade," wrote James Watt in 1784; "they are ignorant brutes; but he exposed himself to this, by showing them the process before it was perfect, and, seeing his ignorance of the common operations of making iron, laughed at and despised him; yet they will continue by some dirty evasion to use his process, or such parts as they like, without acknowledging him in it. *I shall be glad to be able to be of use to him.*"

It does not appear that more than £2,654 was raised from the ruin of Cort's estate towards the loss sustained by the public; and in 1805 the subject was again revived in a very unexpected manner, when the Whigs, in their attack upon the administration of Mr. Pitt, impeached Henry Dundas, Viscount Melville, for alleged malversation in his office as Treasurer of the Navy, though he held that office with success throughout the great naval war with France and Spain.

When Mr. Whitbread, the London brewer, spoke to the resolution for impeachment in the Commons, he averred that he strongly suspected "that Jellicoe was in the same partnership with Mark Sprott, Alexander Trotter, and Lord Melville, as he had been suffered to remain a public debtor for a whole year after he was known to be in arrear £24,000."

Bitter political enmity is said to have inspired Mr. Whitbread, whose speech was unwarrantable in tone, though serving its end, for Lord Melville was tried by his peers at Westminster Hall, and adjudged not guilty.

In the Report made by the Commissioners to the Houses of Parliament in 1805, the year of this remarkable impeachment, the value of Cort's patents was estimated then at only £100. Many of Jellicoe's debts were marked as bad; "and we apprehend," they added, "that the debt from Mr. Henry Cort, not so marked, of £54,000 and upwards, is of that description."

But all these parliamentary discussions availed Henry Cort nothing. With his wife and twelve young children he left his extensive works and handsome mansion, a bankrupt, ruined, heartbroken, and penniless. In vain did he appeal to Government for the restoration of his patents. However, Mr. Pitt granted him in 1794 a pension of £200 per annum; but, broken in health and spirits, he only enjoyed it six years, as he died in 1800, in the sixtieth year of his age.

"In the opinion of Mr. Fairbairn of Manchester," says the author of "Lives of the Engineers," "the inventions of Henry Cort have already added six hundred millions sterling to the wealth of the kingdom, while they have given employment to six hundred thousand working people, through three generations; and while the great iron-masters, by freely availing themselves of his inventions, have been adding estate to estate, the only estate secured by Henry Cort was the little domain of six feet by two, in which he lies interred in Hampstead churchyard!"

Such is the story of the man who founded the iron aristocracy of Great Britain. The small stone that marks his resting-place, with the date of his death, may still be seen. A few years ago it was quite illegible, but the kind hand of a relative has recently restored the inscription.

SHIP-BUILDING.—XVII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DECKS OF SHIPS. (*continued*).

BEAM-END CONNECTIONS.

THIS branch of our subject is very important and extensive, so that no attempt will be made to exhaust it, but rather to illustrate arrangements which are, by common consent, pronounced good. Here, as elsewhere, we will take wood ships first, and afterwards pass to iron and composite ships.

Beam-end connections have long engaged the attention of wood shipbuilders, upon whose notice the matter has been forced by the weaknesses displayed by many vessels. In the old times, when the use of iron, except in the simplest forms, was unknown in ship-building, massive timber knees were used to connect the beams with the ship's sides. The beam-ends rested upon the edge of the internal planking, or "clamps," and were each secured by two knees—one (the "hanging knee") placed vertically, and bolted to the side of the beam and to the clamps; the other (the "lodging knee") placed horizontally, with one arm bolted to the beam and the other to the timbers. This clumsy arrangement has not yet fallen into entire disuse, but is adopted in some North American-built ships. In all probability the abundance and cheapness of timber there constitutes the chief reason for continuing to conform to the old-fashioned plan. In this country the departure from it was made long ago; and the plans which followed have in their turn been improved upon, giving place to others which are now in use. Our concern being chiefly with the latter, we will at once refer to an illustration, in Fig. 54, of the most improved beam-end connection, our sketch representing the practice of the Government service.

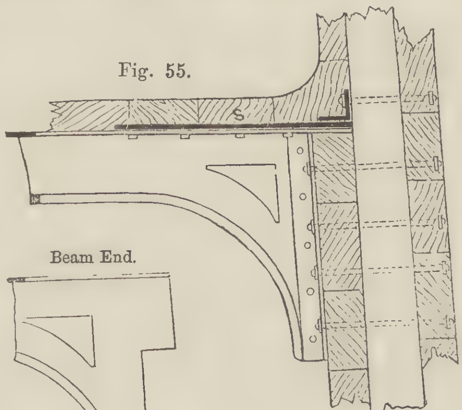
The beam-end is fitted closely against the timbers, great care being required in cutting the beam to the exact length required to ensure an accurate fit when the beam is set to the proper round-up. Underneath the beam-end comes the "shelf," *a*, a strong longitudinal timber, the lengths of which are joined by plain scarfs, well fitted and fastened. The shelf is usually fastened by a bolt in every timber, and also by circular dowels let half into the timbers and half into the shelf. It runs nearly the whole length of the ship from stem to stern, and constitutes a valuable longitudinal tie. Some shipbuilders have not entertained this opinion, and have not considered the shelf as more than a support for the beams; but in cases where this view has been acted upon, and the pieces of the shelf have been butted instead of being scarfed, exceptional weaknesses have been displayed. Sometimes the shelf is not worked directly against

the timbers, as in the sketch, but is wrought inside the upper strake of the clamps, which then extend up to the under side of the beams. Formerly this plan was commonly employed, and the shelf-pieces were of smaller dimensions. A dowel (*d*, in the sketch) is fitted in the bearing surfaces of the beam and shelf; with large beams two dowels are usually fitted.

The beam-knee in this case is an iron forging fitting under the beam, against the shelf, and over the clamps. Its fastenings consist of several bolts with clenched points passing through the clamps or shelf, the timbers, and the outside planking, and of other bolts passing through the beam and clenched upon its upper surface. These fastenings are obviously well distributed, and, by retaining the knee in place, do much to aid it in resisting any change of angle between the beam-end and the ship's side. As compared with the older plans, this form of beam-knee is most simple and efficient, and it has come very largely into use in merchant ships as well as in wood ships of the Royal Navy.

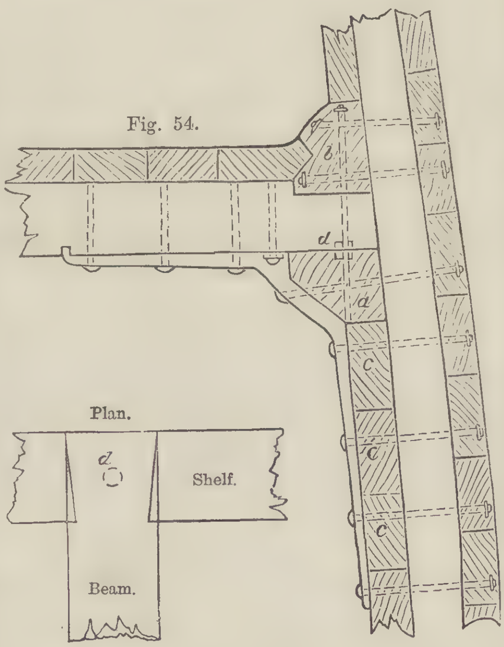
The third element in the beam-end connection is supplied by the thick "waterway," *b* in Fig. 54. This large timber is faced, or let-down, over the beam-end, but the latter is not cut away, except to the small extent required to form the dovetailed seating (shown in the plan) upon which the waterway fits. The fastenings of the waterway to the side generally consist of a through-bolt in each timber, the bolts over the beams being driven in the upper edge of the waterway, and those between the beams in the lower edge. The separate lengths forming the waterway are plain-butted, not scarfed; but the butts are often dowelled to a carling fitted for the purpose, and are thus sufficiently strapped to enable them to contribute somewhat to the longitudinal strength of the structure. The union of the waterway, beam, and shelf, is further strengthened by means of the vertical through-bolt, shown in the sketch. Adjacent to the thick waterway, and let into its front, is the "thin waterway," which forms the side boundary of the deck planking; and directly above the waterway, the internal planking known as the "spirketting" is fitted.

Fig. 55.



Beam End.

Fig. 54.



From this brief description, it will be obvious that the beam is so secured as to be capable of acting either as a strut or a tie between the two sides, and that considerable resistance is offered to change of the angle between the beam-end and the side. It is by no means unusual, however, when wood ships have been severely strained at sea, to find symptoms of slight changes having occurred in this angle, even when the arrangements of Fig. 55—which are probably not far from the best possible with wood beams—have been adopted. One other noteworthy fact is, that by means of the strongly-fastened shelf and waterway, the relative positions of the decks and sides are maintained when the vessel is subjected to longitudinal strains, and so the strength of the decks is developed, notwithstanding their sheer.

Next we will take an illustration of the mode of securing iron beams in wood ships. Fig. 55 will aid our description greatly. The beam there shown is of the Butterley pattern, and has the knee formed by welding in a piece—as described in the previous paper—only a space is left unfilled when the welding is performed. Allusion was made to this practice before, and the openings so formed in the beam-arms are often found useful for leading pipes or other longitudinal fittings along close to the side, where they are out of the way. The beam-end is formed (as shown) with a shoulder, so that it may rest upon the upper edge of the clamps and have its upper part fitted against the timbers. Short pieces of planking are then worked above the clamps, and between the beams, thus assisting in maintaining the beams in place. The main connection with the side is made by double angle-irons on the beam-knee, fastened by rivets to the beam, and by through-bolts to the ship's side. Upon the beam-end, close to the timbers, is fitted a "stringer-plate," s, riveted to the upper flanges of the beam, and secured by an angle-iron to the timbers. This stringer consequently adds much to the strength of the connection, and acts as a horizontal knee to each beam. The latter feature of its usefulness is by no means unimportant, although subordinate to its office as a longitudinal strengthening. For instance, if a ship be heeled over, and at the same time subjected to longitudinal bending strains, there would be a considerable tendency to rack or distort the deck, and to throw the beams out of their transverse position. Against these racking strains the stringer, considered as a horizontal knee, would be most efficient, and, from its great breadth, would probably aid the beams much more than the waterway fitted on wood beams, although the latter gives valuable assistance under similar circumstances. The remaining details in Fig. 55 are sufficiently explained by the sketch; and it will be obvious that the whole arrangement is both simple and efficient, especially in its resistance to any change of the angle between the beam-end and the ship's side. Here the knee is formed as part of the beam-arm, and so shaped and fitted as to render working much less likely than with iron-plate knees and wood-beams, like those of Fig. 54. It is not surprising, therefore, to find that the use of iron beams in wood ships is becoming common; and it will be shown hereafter that other considerable advantages are also gained by employing them.

Iron and composite ships usually have their beams stationed at and directly connected with the frames. One illustration will, therefore, serve for both these classes, and it will be found in Fig. 56. Here also a beam of the Butterley pattern is shown. On referring to the beam marked *aa* in the plan, it will be observed that the web of the beam is fitted directly against the side of the frame angle-iron; that one of the flanges is continued on with the web, and that the other flange is butted against the reversed angle-iron. Should there be no reversed angle-iron on the frame at which the beam is stationed, it is common to fit the beam-web on the "back" of the frame angle-iron, instead of in its "bosom," as in the sketch. If made-beams, or beams formed of a bulb-plate and double angle-irons are used, slight modifications of the arrangement illustrated might be necessary, but these are unimportant. In nearly all cases the main fastenings in the beam-arm are rivets through the frames, spaced either as shown, or else zig-zag fashion, if the frames be of greater depth. The connection with

the side is strengthened by means of a stringer-plate riveted to the upper flanges of the beams; nothing need now be said respecting it further than that it acts similarly to the stringer in Fig. 55; but in our next paper we shall again refer to the subject.

It would be difficult to imagine any simpler or more efficient beam-end connection than that usually adopted in iron ships. Working in any direction is rendered practically impossible, provided that the beams be made sufficiently strong, the fastenings properly arranged, and the pillars carefully fitted. Moreover, it must be remembered that the bulkheads fitted in iron ships afford the beam-arms valuable assistance in preventing changes in the transverse form.

Besides the common mode of securing beams shown in Fig. 56, there are many other plans used under special circumstances. For example, the hold-beams of merchant ships, which are spaced very much farther apart than the deck-beams, are sometimes fitted above a "shelf-plate" (*i.e.* a stringer is worked below instead of upon them), and knees are consequently given up. Brackets or gusset-plates are then usually fitted instead of knees, and indirectly connected with the beams. In other cases no knees are formed on the beam-ends, but triangular-shaped bracket-plates are used instead, being riveted directly to both frames and beams. This connection is almost limited to made beams of I or box section. Other exceptional cases are met with in which the beams are not stationed at frames, but are directly connected with the skin-plating; and this plan was not uncommon in the earlier iron vessels. When special strength is needed, as is the case where beams form the boundaries of the principal hatchways, and for a considerable length there is no complete transverse tie, it is often considered desirable to strengthen the beams themselves, and to add to their connection with the side by fitting deep bracket-plates extending the whole distance between decks. These deep brackets are sometimes termed "partial bulkheads." Besides the above-named, there are other special beam-end connections, which cannot be noticed here; and our remarks on this subject must be concluded by stating that only unusual and unavoidable requirements lead iron ship-builders to depart much from the excellent plan in common use, illustrated by Fig. 56.

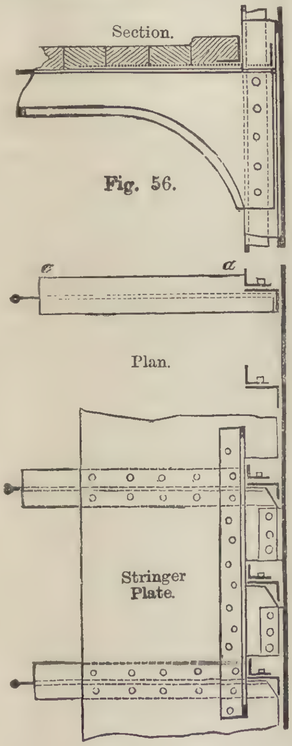


Fig. 56.

DECK-PILLARS.

Reference has been more than once made to the importance of efficient pillaring to the decks of ships; and a few words in the present paper will suffice to render this clear. Every one recognises the fact that pillars are needed as *struts* to support the decks, considered as platforms sustaining heavy weights; but many persons overlook the further very important consideration that under some circumstances the pillars must act as *ties* also, if they are to aid in preventing changes of transverse form. In order that these two requirements may be met, the pillars must be fastened at both their heads and their heels; but this is often left undone, and, as a consequence, the pillars can only act as struts, efficient against compressive strains.

Wood ships formerly had the pillars between decks, and the stanchions, or large pillars in the hold, were formed of wood; but now iron pillars, either solid or tubular in section, are largely employed. Iron and composite ships are always furnished with iron pillars. Tubular iron pillars are preferable to solid, especially for the larger sizes, because, with a given weight of material, they can be made much more efficient against failure by buckling under compressive strains, as well as against bending if struck horizontally. These hollow pillars can now be readily procured, and are largely used, especially in the Government service. The heads and heels are made solid, and forged similarly to those of ordinary solid or bar-iron pillars. With iron pillars it is possible to strongly bolt or rivet the heads to the beams, and the heels to the decks, or beams, or keelsons. Wood pillars cannot be so efficiently fastened; and, as usually fitted, they are not of service as ties against tensile strains. To secure equal strength they also require to be much larger than iron pillars, and this tells further against their use. They are now mainly used, if used at all, in the holds of wood ships.

In order to facilitate the work of pillaring it is customary to place the beams of successive decks directly over one another. The pillars are generally placed in rows, either at or on either side of the middle-line. The pillars, or stanchions in the hold, generally heel upon the keelson. At some parts of a ship it is difficult, if not impossible, to fit pillars to every beam. For instance, in the engine-room of a steam-ship, this is often the case; and it is then usual to fit longitudinal girders along under several beams, the ends of the girders resting upon pillars of exceptional strength. Where concentrated weights have to be supported, the pillars are, of course, both stronger and more numerous. All such arrangements rest very largely with the ship-builder, who can best determine as the work goes on where special strength should be given, and how it may be afforded.

SILK CULTURE.—VII.

By Alexander Wallace, M.D.

CULTURE AND MANAGEMENT OF BOMBYX PERNYI.

One more oak-feeding *Bombyx* requires particular mention, because it has of late years been the subject of experiment—viz., the oak-feeding silkworm of Manchouria and Northern China, *Bombyx Pernyi*. This name was given to it in honour of the French Archbishop Perny, by whose means this silkworm was first sent over to Europe. A few cocoons were at various times received in Paris, but though a few moths emerged, and eggs were obtained, the vitality of the parent insects was so depressed by the long journey that no healthy offspring was reared. A few cocoons, however, were forwarded to England by the late Mr. Meadows, H.B.M. acting consul at Newchwang, some of which were placed in my care. I therefore applied to the then Minister for Foreign Affairs, Lord Stanley (now Lord Derby), and he very kindly acceded to my request, and issued instructions to Mr. Meadows to forward to me for the next four years cocoons of this promising *Bombyx*, and also acorns of the oaks on which the worms were fed. Consignments of these cocoons in quantity have therefore enabled me to make a fair trial of its habits, to observe it closely, and to distribute the eggs of this species over Great Britain and Ireland, some parts of the Continent, America, Australia, and the Cape of Good Hope; and sufficient information is now obtained to enable us to judge of the value of the race for commercial purposes.

We will therefore first repeat here the information received from Mr. Meadows, and afterwards refer to our own observations.

In the commercial report for the year 1865, by Mr. Thomas Taylor Meadows, on the consular district of Newchwang, the most northerly of the ports of China opened to foreign trade by the Treaty of Tien-tsin, and situated in the Manchurian province of Tung-t'ien or Sheng-king, are contained some interesting details, derived from personal investigations, regarding "mountain silk," the product of the larvæ of a moth feeding on oak leaves.* "There are two crops of the mountain

* Mr. W. H. Lay, in his report on the trade of Chefoo for the year 1866, thus refers to what I suppose is the same production:—"Amongst the articles that can be exported from Chefoo there is brown silk, produced from the wild silkworms that swarm in the mountain forests; and the quantity of this article that could be brought into the market,

cocoon, a 'chun,' or spring crop, and a 'tsew,' or autumn crop. The latter is collected in the last half of September, and in October, and the cocoons are brought to market during this latter month. At this period the silk-growers pick out the best of the cocoons for the production in spring of the butterfly and worm for the spring crop. They are preserved in baskets, which are hung up in the Chinese dwelling-rooms. These almost always face the south, thus opposing a blank wall to the cold northerly winds prevalent in winter, and getting from the southerly windows the full advantage of the sun in that season, when, during nine days out of ten, there is a clear blue sky. Besides this the dwelling-rooms are partially heated by the warmth emanating from the surface of the "kang," or brick bench which occupies about one-third of the room, which serves as a sleeping-place at night, as seat, etc., during the day, and inside which is a winding flue with an aperture at one end in which a fire of millet stalks is occasionally lighted. In spite of all this, however, the temperature of a Chinese dwelling in the mountain-silk district is, during the greater part of the winter, considerably below the freezing-point. The worm, being indigenous, could doubtless stand the cold of the winter's night in its cocoon on the bushes on which the cocoon is formed; but apart from theft, destruction by wild animals, insects, etc., it is probable that in nights of unusual severity only the strongest and best enclosed might escape perishing from cold.

"The natural heat of spring suffices to bring the chrysalis out of the cocoon in the butterfly shape. The butterflies then couple, and in about four or five days after impregnation the female lays eggs. They are laid on native paper spread on mats, tables, etc. In about five or six days from each of these eggs is produced a small worm of about the size of a black ant, which is black in colour. This is about the time when the buds on the oak-bushes have begun to make their appearance: this must be in the last half of April. The young leaves are forced by twigs being cut off from the bushes and placed in water, in pools of the mountain streams, or in tubs in houses. From these the young tender leaves are taken, and are scattered over the paper as the worms appear from the eggs. The worms are thus nourished for some days, when they are transferred to the youngest, most tender-leaved oak-bushes on the hill-slopes. They are then about an inch in length, but are still black in colour. The transfer of the whole does not take place in one or two days. There is, during the whole existence of the animal in its worm stage, a difference of eight or ten days in the backwardness or forwardness of individuals.

"After some days the worm has its first sleep or torpor, at the close of which it changes its skin, and re-appears green in colour and larger in size. It has in all four of these sleeps or torpors, each of which lasts about two days. It changes its skin and becomes larger after each torpor, but retains, after the first, the same bright-green colour. For its next or fifth sleep it prepares by spinning itself into a cocoon, in which it assumes the chrysalis shape; then bursts out as a butterfly, and lays eggs, from which the small black worms are produced, when the processes just described are gone through again. These processes are, in the spring season, more rapidly performed than the similar processes in the autumn. The silk-growers told me that those of spring required about sixty days, those of autumn about one hundred. In each season, as fast as the worms consume the leaves on one bush they are removed by the attendant silk cultivators to another, the youngest bushes being used first.

"The worm is fed on three kinds of oak bushes called 'small tsing-kang-lew,' 'large tsing-kang-lew,' and 'hoo-pŏ-lŏ.' The only difference between the small and the large tsing-kang-lew seemed to me to be in the acorn cup, that of the former being smaller and also smoother outside than that of the latter. As for the hoo-pŏ-lŏ oak, its leaves are much larger and darker than those of the large or small tsing-kang-lew. Its acorns are also much larger, and, what at once marks the difference, the cup, instead of a hard exterior rendered more or less rough by small hard protuberances, is covered with longish feathery filaments, which give the cup the appearance of a small fur cap.

"The yield of the spring crop is said to be much less than that of the autumn crop—1,000 cocoons of the former giving no more than 500 of the latter; but the quality is said to be greatly superior, finer, whiter in itself, and more capable of taking dyes; but black, with various shades of reddish-brown or purple, seem to be the only dyes that either kind will take.

"The chrysalids which are not kept for breeding are used by the Chinese as an article of food.

"The mountain silk remains as yet the one article which this district is likely to furnish to England. My explorations of last summer convinced me that I did not, in my last report, over-estimate the extent of country in which it is produced, when I said 150 miles by 100. On the other hand, instead of saying that not one-fourth part of the hill-sides suitable for the oak-bushes is planted with them, I should now say that not one-tenth part is so planted. Viewing the nature of the article and the quantities that are now, and that could be furnished, the trade could be developed into one of appreciable importance even for our great manufacturing interests, unless exactions and jealousies of the local mandarins interposed to repress it."

The following remarks on the climate are also from Mr. Meadows's report:—

"The result of our five years' experience of the climate may be given here.

"The following is a table of the extreme temperature observed. It gives information much more required by the proposing resident or traveller in new countries than mean temperatures. It shows him what extremes of heat and cold he will have to encounter at times, and for which he must be prepared, or suffer severely in consequence. For mean temperatures people are rarely insufficiently prepared. The chief practical defect of the table is, accordingly, the absence of a column showing the heat of the sunshine in summer. The observations from which it is made were all taken from Fahrenheit's thermometers, suspended on the northern faces of house-walls, on which the sun never shines, therefore in the coldest and coolest places.

Month.	Coldest.		Warmest.	
	Morning at daybreak.	Afternoon at 2 to 4 p.m.	Morning at daybreak.	Afternoon at 2 to 4 p.m.
January	...	3°	39°	...
February	...	7	35	...
March	0°	14	43	44°
April	27	41	53	50
May	41	52	65	60
June	57	70	76	68
July	62	74	79	74
August	63	73	77	85
September	41	52	73	80
October	28	42	66	71
November	7	17	52	61
December	6	2	37	44

"The coolest months are December, January, and February. The greatest cold of a winter may occur in any of these months, but is most likely to occur in January and first half of February.

"The warmest months are June, July, and August. The greatest heat of a summer may occur in any of these months, but is most likely to occur in July and first half of August.

"The number of days in any one winter on which the thermometer stands at daybreak below zero does not exceed ten; and it rarely is below zero for more than two mornings in succession. In the coldest winter afternoon it always rises above zero.

"In a cool room with Venetian blinds the temperature does not rise above 80°, except for a few hours during some twenty-five to thirty-five afternoons in each summer, and these comparatively hot days do not occur together, but are distributed, with cool intervals, in groups of three to five, throughout June, July, and August. In these months the temperature always falls below 80° during the nights. In exceptionally hot summers, as in that of 1862, the thermometer may stand at daybreak at 75° to 79° for some twenty days; in cool summers it rarely stands above 70° at daybreak. As to the highest tem-

if prices suited, may be computed at not less than 12,000 bales a year. This silk is of different qualities, according to the process and care adopted in reeling it from the cocoons; and some of it is well adapted for manufacturers. The natives weave plain silk goods from it called 'pongees,' and about 100,000 pieces of these stuffs could be bought annually."

perature of the table, that of 85°, it has only once been attained in my library during five years; that was on 31st July, 1862."

All the preceding remarks refer to the climate of the port of Newchwang. The northern portions of the consular district of Newchwang are very much colder in winter, and have shorter and cooler summers.

The mean temperature of Pekin, as deduced by Kuppfer from thirteen years' observations, is—Spring 51° 8′, summer 68°, autumn 50° 4′, winter 29° 4′. A comparison of the temperatures of various European cities, as given in Mahlmann's elaborate tables, in the third volume of Humboldt's "Asie Centrale," will, I believe, prove my assertion.

It is therefore highly probable that on the hilly ranges where the *Bombyx Pernyi* breed the temperature will be found cooler even than that quoted by Mr. Meadows as peculiar to Newchwang.

The extreme hardiness of the race will first be noticed as contrasting greatly with the *Yama-Maï;* and all European experience bears me out in saying that this insect, in point of vitality and a hardy vigorous constitution, far exceeds the *Yama-Maï.* Indeed, the ease with which it has been transplanted, so to speak, into Europe, Africa, America, and Australia, and the difficulty which has attended the acclimatisation of the *Yama-Maï*, corroborates my statement that the *Bombyx Pernyi* is originally of a very vigorous and hardy constitution, and will thrive readily in other climates than its own. It will also be noticed that this insect is double brooded, and this, though an advantage perhaps in such climates as Australia and the Cape of Good Hope, which possess long summers and short winters, is a disadvantage in Great Britain, where our short and uncertain summer precludes the possibility of a second generation, except in very favourable seasons. This disadvantage also pertains to the *Bombyx Cynthia*, and, as in that insect, may be overcome by encouraging the adaptability of the race to the local peculiarity of the climate. Thus, by retarding the cocoons in the spring, and by adopting the same measures in the autumn, one generation can easily be obtained without much risk of a second. To this end the cocoons should be left in a cool cellar or out of doors in the shade, and in the autumn may even be preserved in sawdust in a hamper, and placed in a refrigerator, without detriment. This, therefore, is not the disadvantage practically which at first sight it appeared to be, and, as in the case of *Bombyx Cynthia*, an English acclimatised race of *Bombyx Pernyi* would gradually get accustomed to the climate and have normally but one generation. The climate of the country round Newchwang seems somewhat to resemble that of Northern Germany. The rainfall, as given by Mr. Meadows, is moderate, 22½ inches per annum being stated as an unusually high average; and a prevalence of strong winds is also noticed, which would materially lessen the temperature in the hilly regions where these worms are cultivated. It cannot, therefore, but be otherwise than that the temperature in these hills will have a lower average than that quoted by Mr. Meadows at Newchwang.

With regard to the oaks on which these larvæ feed, specimens of leaves and acorns have been sent to me and also to Kew Gardens, and from these materials the species of *Quercus* have been accurately determined. Two of these, called respectively, large and small "tsing-kang-lew," appear to be *Quercus Mongolica.* Another, called "hoo-pŏ-lŏ," is *Quercus obovata Buuge.* The leaves of this kind of oak are larger and darker in colour than those of *Quercus Mongolica;* there is also a marked difference in the acorns, which are also larger and darker in colour, and covered with long and tapering scales, thus giving to the cup the appearance of being covered with long brown fur, which also partly covers the acorn itself. A fourth species, called "tseen-tse-tszeo," is the *Quercus serrata* of Thunberg. The silkworms fed upon this oak produce the best silk. This tree, however, is not so common in the silk districts as either of the other species. The next best quality of silk is obtained from the leaves of the *Quercus Mongolica;* those obtained from *Quercus obovata* producing the most inferior description. In this country the larvæ seem to prefer the leaves of the ilex or evergreen oak, also of *Quercus cerris*, the Turkey oak, and the variety known as the Lucombe oak; but it has also been easily reared on our common oaks, *Quercus pedunculata* and *Quercus sessiliflora.*

The cocoon is large and heavy, weighing from 80 to 200 grains, of a greyish yellow-brown tint. The inside cavity is much larger than the chrysalis, hence there is a danger in transporting these cocoons for a long distance, for the pupæ inside may get bruised and injured by the shaking endured in the journey. It is attached by a pedicle to the branch, and is thus intended to remain suspended (all the winter if necessary) till the moth emerges. It is of a somewhat loose texture, and the apex is less closely spun than the cocoon of the *Yama-Maï*, hence arises some little difficulty in reeling. The moth is large, pretty, uniform in tint, of a greyish brown colour, more or less suffused with reddish brown; the males have magnificent large antennæ-organs which, when largely developed, are generally concomitant with large powerful wings and a restless habit, intended evidently for ranging over large areas in search of the female.

A clear ocellus in each of the four wings, which are falcate at the tip and very powerful, make it a typical example of its genus, *Antheræa.* The female is large, sluggish in flight, full of eggs: the wings are broader and less falcate than in the male.

The egg is light brown, very like that of *Yama-Maï* in size and appearance, except being somewhat less flat and of a lighter tint. From 300 to 400 may be laid by one female. The egg state lasts in warm weather about fourteen days; and the larvæ hatch out in early morning, vigorous black little wanderers, restless in their habits, and partial to a drink, and even to consume their empty egg-shells; impatient till they get on to the oak leaves, where they mostly prefer to sun themselves on the upper surface of the leaf; gregarious at first, totally unlike in habits and appearance those of the *Yama-Maï.*

After the first month a great change appears, for the larvæ lose their gregarious habits, have a green tint, and almost exactly resemble the larvæ of the *Yama-Maï* to the end of their career, except that their heads remain brown and are spotted with darker markings, whereas the heads of the *Yama-Maï* retain a green tint, while underneath the body of the *Pernyi* a red chocolate-coloured central line is manifest, which is absent in the *Yama-Maï.* The general ground-colour has a more yellow tint, and the spines are longer, and clubbed at the tip like the antennæ of a butterfly. This is wanting in the *Yama-Maï*, and is indeed quite unusual in lepidopterous larvæ. They eat more and grow faster also than the *Yama-Maï* larvæ, are less inclined to drink, and much less prone to disease. Indeed, they have been very successfully turned out in this country on the oak hedges, and allowed to take their chance year after year, and have spun their cocoons. Just before spinning the larva is a monster in size; and as he prefers to take his station at the tip end of a spray from which he has eaten all the leaves, he becomes an easy mark to birds. In one very important matter this species is inferior to the *Yama-Maï*—the cocoon is not so easily reeled. Indeed, though the Chinese are said to reel this cocoon—and, according to Mr. Lay's report, the pongees, an article of considerable supply and demand, are made and woven from the silk to the amount of 100,000 pieces annually—we are yet unable in Europe to reel it, and this is due to the apex of the cocoon being insufficiently closed by the spinning larva. When this difficulty is overcome—which it will be one day—then the cocoons of *Bombyx Pernyi* will rise considerably in value. It has also another disadvantage: the colour is a greyish yellow brown, and not so favourable as that of the *Yama-Maï;* it is also less easily dyed. For carding purposes it has been very favourably spoken of by a gentleman who kindly experimented for me with some of the cocoons, and it produced a strong but soft and pleasant-feeling thread.

If, therefore, it could be produced in quantity at little cost it would prove a valuable commodity, wherever naturalised and localised, so that, without much labour or oversight, the larvæ could be reared out of doors on the trees, without destruction from birds and other enemies, in large numbers. If, in fact, the cocoons could be gathered from oak bushes much as gooseberries are gathered from their bushes, then, no doubt, a good profit would accrue. But this state of things can scarcely be hoped for in England, but rather might be looked for in Australia, New Zealand, or the Cape, where it is reported to me that the ailanthus silkworm, *Bombyx Cynthia*, is similarly cultivated. And with regard to these countries, those possessing the drier climate seem most suitable for the *Pernyi*, while the *Yama-Maï* would do best in the moister regions. It must not be lost sight of that the pupæ are reported to be consumed as food by the Chinese.

About this *Bombyx*, therefore, there seems to be much

promise. It is evidently a hardy vigorous kind, easily reared; and if, by its means, oak leaves can be converted into silken produce for the use of mankind, its value in the scale of creation is by no means contemptible.

PRACTICAL APPLICATION OF THE FINE ARTS.—XIII.

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THE ART OF BOOKBINDING.

INTRODUCTION—FOLDING—ARRANGING AND COLLATING—BANDS AND SEWING—FORWARDING.

It will be requisite, in order to show how the general principles of Art are to be applied to the special art of bookbinding, to describe in detail the various processes (in some cases very peculiar) that belong to this branch of industry. This will be the more requisite, not only because the majority of people know scarcely anything about the details of this art—which is not to be picked up by looking either at the covers of well-bound books, or through the windows behind which bookbinders are at work—but also more particularly because there are but few accounts in cyclopædias of the individual steps, and these accounts are all more or less imperfect, and brief even to obscurity.

The art divides itself at once into two branches, though there is much which is common to both these classes. These two divisions are *cheap* binding and *good* binding—not that it is necessary that cheap binding should be bad, it only does not partake of the strength and excellence of the good; but it is necessary that good binding should not be cheap, inasmuch as expensive materials and skilled workmanship, extended over a considerable time, must be employed.

Folding.—As is known to most persons, the paper employed by printers is of a few sizes, differing somewhat, but not greatly, from one another: these are called foolscap, crown (octavos, quartos, and folios), super-royal (27 inches by 19), imperial (30 by 21), foolscap (18 by 14), demy (20 by 15), medium (22 by 17), royal (24 by 19), columbia (34 by 23), atlas (33 by 26), double elephant (40 by 26), antiquarian (52 by 31). These sheets are simply doubled in half for folio, into four for 4to (quarto), eight for 8vo (octavo), in twelve for 12mo (duodecimo), into sixteen for 16mo, eighteen for 18mo, and thirty-two for 32mo, 48mo, 64mo (see Thumb Bible), lower than which we do not know that paper is ever folded. The folding is done by women, who have an instrument called a folder, or a folding-stick, like a small paper-knife, made of ivory, boxwood, or some similar material. The edges are neatly brought together, then the folder brought sharply up to the inside of where the crease is to be, and lastly run along the outside of the crease. The neatness and accuracy of the folding adds considerably to the beauty of the book, since, when the edges are all even it is only necessary to cut off a very small portion to make them smooth, and thus we get what bibliopoles call "a tall copy." There is much difference amongst women as to the number that they can fold in a day. A quick hand will fold as many as 3,000 sheets a day, though some do only half that number.

Arranging and Collating.—As soon as the sheets are folded, they are arranged according to the letters, called *signatures* or *catch words*, at the bottom of the first page of each sheet. This work is also done by girls; and in some cases as many as 25,000 have been gathered by one girl in a day; but the girls' work is afterwards examined by a superintendent, who also cuts out any portions left blank by the printer in the first or last sheets. In the case of maps, diagrams, and illustrations, these have to be added afterwards, and this is done by the *Collator*, who cuts the engravings to a size which will bring them to the middle of the page when the rough edges of the book are cut off. Naturally this requires great care and some experience, so as not to cut too much, and so thrust the print too far into the book to be seen with advantage, nor to leave it out so far that the edge is left narrow.

Bands.—The book is now returned to the women's department—after being beaten, pressed, or rolled between cylinders—and it is sewn upon the bands. These bands differ in number, according to the size of the book and the character of the binding. Cheap school-books, for instance, sometimes have only two bands, but most books have four or five, whilst large, strongly-bound books require six. The bands are pieces of strongish string, or cord, which are fastened perpendicularly at fixed distances on a frame rising at the edge of a board, on which the sheets of the book are placed one by one. A sheet is placed on the board, with its folded back against the upright bands; it is then opened by the left hand of the operator, who with her right hand runs a needle, threaded with strong thread, through the sheet against the first band, to which the thread was originally attached. The needle is brought out beyond the second band, around which the thread is passed, and the needle again enters the middle of the sheet, and passes on to the next band. When the last band is reached, the next sheet is laid on, opened as before, and the threaded needle passed from band to band the reverse way. The ancient binders carried this sewing up to the headings of the pages, around which also they passed the thread; that process (called flexible, or monastic) is abandoned now, and the little piece of vellum, bound round with silk, at the top and bottom of the book is now added at a later period of the process. In the best binding the hole for the thread is made by the needle, and the band stands off from the back of the book, whereas in the cheaper and quicker work all the holes are made at once by a saw passed along the back, and in the groove thus made the band lies. The disadvantage of this step is, that the book will not lie so flatly open. When the whole of the sheets are sewed, the bands are cut off at some little distance from the book, and the ends thus left are afterwards unravelled, and spread out, so that they may catch as firmly as possible on the boards when glued for common binding. For good binding the slips are drawn through the board. When the book is sewn, but the leaves are still loose, the back is covered with glue, which penetrates some little way between the leaves, joins the various sheets together, and fixes the plates, etc., in their places. This glue must dry, and then the book goes to another department.

Fig. 1.—SEWING.

Forwarding.—The book now passes from the women to the forwarding room, where several processes occur. First it is pressed between two wooden boards, about three-eighths of an inch of the back projecting beyond the boards, one-eight to 8vo, and so on according to the thickness of the millboard. The workman

then, with a short-handled, heavy hammer, having one face large and flattened, and the other a blunt edge of nearly two inches wide, beats down the leaves, beginning with those nearest the boards, over the edge of them. This is first done with the edged face, but when the whole of the leaves have been beaten so as to incline to one side or the other, the whole is made into an even curve with the flat face. The process of beating the side leaves will have brought up the middle sheets, and will have caused a corresponding concavity in the front of the book. There is some little knack required in this process of beating down the back. A clever workman will, with a considerable number of blows adroitly given, beat the whole line of the back, so that when the book is opened wide the crease at the back will appear quite straight and even; but in a badly-bound book, done rapidly and carelessly, the crease will be irregular and uneven. To judge of whether a book is well bound or not, it is necessary to open it wide in several places; if it lies flat when opened, and the crease is one straight line, the work is good; but if the book closes itself, and has a number of irregular creases, it has been done quickly and unsatisfactorily. The wooden boards, too, by their pressure, will have left an indentation, into which the backing-boards, which are now always made of millboard, of greater or less thickness, can now be inserted. The monkish binders used to use wooden boards not unfrequently, but these are never employed now unless to humour the fancy of a customer. These boards have holes, through which the bands are inserted and glued. The leaves have now to be cut. The whole back is now rubbed hard with stiff paste on the glue, which has dried, and has been beaten round. This paste not only adds to the adhesiveness, but it also makes the glue less brittle and less liable to fall off. The cutting of the edges is done by pressing the book again between the two boards, one projecting beyond the edge of the book, the other being accurately placed on the line which it is desired to cut. A knife, which is fixed in a wooden machine to work evenly on the board, and is called a "plough," is passed backwards and forwards along this edge, until the whole book is cut through to the opposite board. This process is easy enough with the two ends, which are flat. With the face, the only requisite is to beat the back flat before the book is screwed up tight; it then makes the face flat after it has been cut straight; on the book being allowed to take its original curved shape, the front edges adopt the corresponding curve inwards. The edges of the leaves can now be coloured. Sometimes they are only sprinkled. This is done with a large hog's-hair brush, partly filled with colour, and jerked over them. The ancients used sometimes to blacken the edges with antimony in fine powder, rubbed on the damped edges, and burnished. Sometimes vermilion is rubbed on, with a little mucilage to make it stick. This too is burnished until it shines. Occasionally, in addition to these red edges, but more frequently without the red foundation, after having been simply rubbed with yellow-red ochre and size-water, the edges are gilt, which process is the same as ordinary gilding. Some white of egg thinned with water, or some similar mucilage, is applied to the edges of the leaves, and the requisite amount of gold leaf laid on. This gold is dried, and then burnished with a dog's tooth, agate, or bloodstone; and when the book is opened each leaf takes its own little modicum of gold. In some rare cases the edges are scraped before they are gilt. The most curious process is that of marbling, which is performed in the following manner:—A strong ley is made of linseed and fleeseed (gum tragacanth is the best); this should be of the consistency of cream, or thereabouts, and is spread over the surface of a wide but shallow trough. In the meantime colours are prepared by being ground very fine, with a small portion of ox-gall. These are thrown one after another on the surface of the ley, a little more ox-gall being added to each as it comes later in order. Those colours are left till the last, which appear most in spots on the top of the streaks of other colours. The ox-gall prevents the colours from mixing with one another, or with the somewhat oily mixture below; consequently each takes its own place in spots or streaks, as it may be thrown on the surface. We now have on the trough a surface of many colours, in those peculiar shapes we call marbling; all that remains is to dip the edges of the book, and the front, flattened as before, when it

Fig. 2.—FORWARDING.

Fig. 3.—FINISHING.

had to be cut, upon this coloured surface. The embossed surface takes up the colour to which it is applied, and only requires drying and burnishing. Considerable variety is caused in the character of the marbling by inserting a comb, and with it a slight amount of streaky small curve-like waves are produced; or by putting a stick in various places, and in each obtaining a little vortex around it; or by similar means: by tilting the trough a slight wave is produced, which will cause lines of greater or less intensity of colour. In this remarkable and amusing process there is plenty of room for ingenuity and taste, and an experienced workman may obtain considerable credit for his combinations of colour and form; whilst to the spectator beholding the process for the first time it is certainly a source of much amusement. When all the books have been marbled that are ready at the time, the remainder of the colour can be used up in staining paper for the insides of the covers, or for similar purposes.

The edges being coloured, the backs and boards are washed over with size, and are ready to be transferred to the men who put the actual cover on the book, be it leather, cloth, or paper.

As this introduces a new and a lengthy subject, we must reserve it for a future paper.

SANITARY ENGINEERING.—XXIV.

THE VENTILATION OF SEWERS.

Of all the questions involved in theories of sanitary engineering proper, this may perhaps be considered the *crux*, or crucial difficulty. The unwholesomeness of sewage arises from the deleterious gases evolved from fæcal or decomposing animal matter. Supposing, therefore, sewers to be thoroughly ventilated, these noxious elements are of course removed, and dispersed in the surrounding atmosphere, and the sanitary success accomplished. We are far, however, from having hitherto arrived at that desirable conclusion; and let us first remark that the circumstances to be dealt with are very different from those attending an ordinary limited area of house-drainage, which, by the judicious application of certain well-understood principles, may be made self-ventilating by the adoption of the methods indicated in our late paper upon the subject, or in some similar way; and we at once illustrate our meaning by referring to what is still the standing authority upon the question, the Report of W. Haywood, Esq., Engineer to the Commissioners of Sewers, published in 1858. At page 51, he says: "There are in the City of London 45½ miles of pipes large enough for men to enter, and 2½ miles of pipe sewers. To these sewers there are about—

2810 gullies of every description;
1065 air-shafts, with ventilators.

3875 openings to the sewers from the public ways."

And, by a further calculation, he arrives at the figures, that the total length of house-drains existing in the City must be about 168 miles. All these drains, of course, are more or less pervious to the external air, either from defects in the construction, bad jointing, imperfect trapping, or the absence of any trapping whatever—though this last defect is, no doubt, far less prevalent now than at the time when his report was made and published. Yet we may fairly take it that the extent of the drainage system, and most of its general conditions, are much in the same state now as they were then, though, doubtless, there have been many modern improvements introduced in matters of detail. Our object is not, however, to report upon the present condition of drainage in the City: we simply quote the figures as supplying some sort of basis upon which an idea may be formed as to the difficulty of the general problem—the ventilation of sewers. Various schemes have been propounded at different times, many of them fully considered in the Report above quoted; and we may venture to say that the conclusion to which most authorities upon the subject have arrived is, that the ventilation of any existing system of sewage must be a carefully considered question of detail. We instance the City first, as there—probably from the large proportion of population to area, the confined width of many of the streets, and various other local causes—the difficulties that have to be met are at least as great, if not greater, than are to be met with elsewhere; and yet we may state, without contradiction, that the hygienic statistics of the City contrast well with many other portions of the metropolis, and are in satisfactory advance of some of our larger provincial centres. Ventilation by means of an air-gully in the centre of the street, at certain intervals guided by circumstances, aided occasionally in very narrow throughfares by ventilating pipes conducting the sewer emanations to the level of the chimney-tops of the adjoining houses; a careful attention to flushing and cleansing the drains as requisite, and an abundant supply of water, may be mentioned as the most efficient means, either in London or elsewhere, of providing for the easy and innocuous escape of sewer gases.

The currents of air that travel through the sewers are subject to the most uncertain laws. This fact, however, seems to be established, that in any district in which there is considerable variation of level, the usual course of matters is this: the ventilating gullies in the upper portion of the district act as up-cast, and in the lower portion as down-cast shafts. But we may broach the theory here, that the more a district is subdivided, and the more ample provision is made for the self-acting ventilation of each particular section, the more perfect the result is likely to be. Experiments were made in Paris, and also in Antwerp, many years ago, with a view of ventilating a large area of sewage by a lofty chimney, the ventilating power being either a furnace or a fan driven by mechanical means; but in each case the result was only partial; as we may well imagine that the influx of fresh air necessarily created by the powerful draught from the numerous openings and gullies neutralises its effect beyond a comparatively small radius of the centre of its sphere of action. We may ask our readers—especially those with some technical and mechanical knowledge—to refer to the figures quoted above as relating to the City of London, and judge for themselves whether any system of artificial ventilation from a central point does not strike them from the first as chimerical, if not on the score of feasibility, at all events on the score of expense. Many such ideas have been started, and some of them are fully dealt with in the Report we have quoted above, and from which we again append the result of some valuable observations as to the comparative temperature of sewers as compared with the upper external air at various seasons of the year. We find at page 84:—"Inspection of the tables will show that between 9 a.m. and 6 p.m. of some days of the summer months, when the external temperature at the period of reading ranged from 55° to 72°, the mean being 65°, the mean temperature of the sewer was 62°, or 3° below that of the open air;" and the Report goes on to show that when such a state of things existed no ventilation could be depended upon for an up-cast draught, and therefore the effluvium from the sewers become unpleasantly evident. Also, further:—"The mean temperature of June, July, and August, registered at Greenwich for a period of fourteen years, was about 61°; the mean temperature of the sewers during those months may be taken as about the same. Thus, during three of the most important months of the year, when the nuisance from sewers is the greatest, these shafts would be useless."

The average difference at night between the minimum open air temperature and that of the sewers may be from 12° to 15°, and therefore we may fairly assume that any system of ventilation, as adapted to sewage, is more efficient at night, although, as we have shown in previous papers, the actual quantity of sewage passing is very considerably less in the night than during the day. "A difference of 6° may be said to exist throughout the year."

It must also be borne in mind, in dealing with all questions of the ventilation of sewers, whether in London or elsewhere, on an extensive scale, that we have not a new, recently erected, well-considered, and complete scheme of construction to deal with, but in many instances, we might almost say, a thing of shreds and patches, the date of many improvements being each marked by the class of work done at that particular period. Many of the sewers now actually in use in the neighbourhood of London were constructed more than fifty years ago, and have all the defects in section and construction of old-fashioned work of that date. So much for actual structural difficulty as to any combined system. With regard to the control of matters in detail, we again quote:—

"I do not anticipate that the three-quarters of a million of inlets to the metropolitan sewers can be by any amount of inspection kept in such a perfect condition that imperfect traps in houses, inoperative gully-valves, the opening of side entrances, the reparation of drains, will not cause a vast amount

of leakage which will present one of the principal if not the main difficulty to be overcome." Now in this element of what is called leakage lies, to our mind, one of the greatest elements of actual assistance to the ventilation of sewers, as considered in detail; for be it remembered, that as the foul air escapes it must be replaced by fresh in some way or other; and this object once attained to a sufficient extent, the only other object is so to arrange matters that the foul air may be allowed its vent at points where it is least perceptible to the public—or we should rather say, least deleterious—and we most emphatically protest against any attempt at hermetically sealing any very large section of drainage of any description whatever, where natural ventilation only is employed; as, if this is done, should a defect exist anywhere within the limits of a private house, most disastrous results may be expected to arise.

The foregoing remarks may be taken as applying to any extensive system of sewers, either in the metropolis or in the great provincial centres. In country towns, where there is abundance of air-space, the same difficulties do not exist in the same degree; but at the same time, bearing in mind the risk arising from the fact of any system of drainage communicating with houses in which stoneware drains are used, the necessary precautions for the escape of the gases should never be neglected, and there are some peculiar conditions under which express attention to this point is very desirable—*e.g.*, in all cases which are subject to tidal influence. Many of our sea-port towns which drain into the sea, discharge only at the time of low water. As the tide rises the sewage in the drains finds its level, and perhaps for several hours out of the twenty-four the lower section of the pipes does not discharge, but becomes for the short period in question a mere receptacle for sewage. In these cases a special provision for ventilation by means of shafts or otherwise is very desirable.

The circumstances under which different systems of drainage have to be constructed vary so entirely that it is impossible to lay down any fixed method for general adoption. Our object has been to point out the nature of the danger, and to indicate the general principles to be adopted f sanitary protection. Closely allied to the question of the ven ion of sewers is that of the disinfection of sewage gases. W have already alluded to the subject, and given some general data in relation to house-drainage only. In our next paper we shall take up the subject of disinfection of sewage, solid and liquid, upon an extensive scale, giving an account of some of the largest operations now carried on for the purpose in the metropolis and elsewhere throughout the country.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XI.—NATIONAL MUSEUMS (*continued*).

Style of Architecture.—Not being conversant with architectural construction, I have only indicated the requirements of curators in the preceding description of what modern naturalists conceive a national museum of natural history should comprise, without attempting to indicate in any way how such a skeleton should be clothed with the garments of art. The Pointed Gothic style of architecture is much in vogue at the present day, as it is said to be "an elastic style," readily adaptable to any requirements; but it seems to me that the so-called "Palladian Style" (illustrated at page 9, Vol. IV. of THE POPULAR EDUCATOR) is well adapted to the plan of building previously described, as it is two-storied, with unencumbered windows, admits of a cupola, bold portico, statues of celebrated naturalists, preferably on the pedestals of the balustrades than among the chimney-pots, or, as at the University of London, in niches, that would help to break the lower line of wall below the windows, as these, by requirements of wall-cases, can only commence nine feet from the lower floor. In short, it is simple and inexpensive, yet withal bears a classic aspect.

As to internal decorations, a hint might be taken from the Oxford Museum, especially if the Gothic style be adopted—viz., to utilise all shafts, pillars, etc., for the illustration of petrology, by making them of various kinds of granite, serpentines, marbles, limestones, sandstones, slates, conglomerates, etc., of the different geological formations, and crowning them with capitals and corbels, carved with natural objects, representing chiefly groups of typical plants, sometimes with animal forms geographically and naturally associated with them, as *Bromus* (wheat, barley, oats, Indian corn, and sugar-cane) with sparrows; rice, and canary-grass with buntings, canaries, and quails, similar to a typical illustration of *Gramineæ* that ornaments the capital and corbels which surmount a shaft of Limerick mountain limestone at the Oxford Museum. If the University of Oxford can afford thus to deck its sanctuary of science, surely the British nation can follow its example. Dr. Acland's "Remarks on the Oxford Museum" are well worth consulting by all persons interested in the decorative details of museum architecture.

Details of Gallery Construction.—On referring to the "Estimate of Space for New Museum," Vol. III., p. 320, it will be noted that the length of certain galleries would have to be increased by the re-distribution of other departments, according to the requirements of modern naturalists. Thus, mammalia requires a length of 850 feet; to this Professor Owen adds 550 for mammalian osteology; and the memorialists of 1858 would make a considerable further addition by blending the fossil with recent mammalia, together with dissected and embryological preparations, models, etc. In other groups mimetic illustrations must be added. As it would be impracticable to have galleries of, say over 1,500 feet in length, of one class, the required length must be gained by the system of reduplication of wall-cases, pre-

Fig. 7.

viously described, and now shown in Figs. 8 and 9, whereby in a straight length of 35 feet a frontage of even 115 feet could be attained *on each side* of a gallery, by throwing out the projecting cases 20 feet, or a total frontage of 230 feet, with space for table-cases in each recess. In the latter case each bay would constitute a separate room, with a gangway 10 feet wide. For cleanliness, the space above the cases might be covered with Minton's plain or ornamental tiles, and white ones where reflected light was needed.

Details of Studies and Keepers' Rooms.—The arrangement of the private rooms is shown in Fig. 7, in a section taken at right angles to Fig. 8. They are arranged on two floors, the lower one being the study, reached from the public gallery, and devoted to the same class of objects; the upper floor being the work-rooms of the keepers, assistant-keepers, and other officials—the communication between the two floors being by a spiral staircase. The studies are filled with tables, T, of various widths—two, three, and six feet—facing lofty windows, L, looking out upon the interior open court. These tables should be supported on blocks fitted with store drawers, with interspaces for chairs, to keep each student's space distinctly separate; the tables next the window being devoted to microscopic or other minute examinations, those farthest away for the larger objects. Each end of the studies would be fitted with book-cases for the special class-libraries, placed on each side of the intercommunicating doors. Every study should be supplied with dissecting and compound microscopes with powers and appliances suited to the special class of study, as, for instance, goniometers, polariscopes, etc., in the mineralogical studies.

The official apartment above would be fitted round with presses,

A to F, for drawers, trays, book-boxes, etc., according to the nature of the objects to be stored, and from this room access would be obtained to the store-cases, K, ranged behind the wall-space above the wall-cases, W, of the public gallery. In fact, the principle of arrangement of studies and keepers' rooms would be to *make provision* for every available space being utilised for storeage according to the progressive annual increase of the collections. By this arrangement the work of the keeper and his officials need not be interrupted by the advent of students or naturalists with whom the staff might be personally acquainted, except to meet their special requirements for information, as subordinate attendants could supply the wants of those visiting the studies.

Details of Library.—In all the plans hitherto proposed provision has been made for a central library from which books could be taken to the studies, so that the difficulties experienced at the British Museum might be surmounted in regard to the complaint that "the books cannot be brought to the specimens nor the specimens to the books;" but I believe it would be found far more convenient and practical, as involving a great saving of time, if the books, memoirs, and papers* on descriptive, analytical, and systematic natural history, were distributed among the studies according to the subjects to which they specially pertained, so that each study should contain its own special bibliography—an opinion in which I am confirmed by Professor Agassiz, who has recently re-arranged his museum library on this system. Each study should be supplied with geological and physical maps showing the distribution of the class of objects it contains. Works on general natural history might be consulted in a small library attached to the private rooms of the heads of departments placed in the supplementary buildings, B (Fig. 4).

Professor Owen considers, that as ninety-nine out of a hundred who would consult the "Banksian Library" would be naturalists, it ought to be removed from the British Museum Library, and go with the natural history collections to the new Museum, especially as Dryander's very perfect printed catalogues of that library are in the possession of most naturalists. If this were done, the cost of a duplicate natural history library of modern books, etc., for the new Museum has been estimated to cost £10,000.

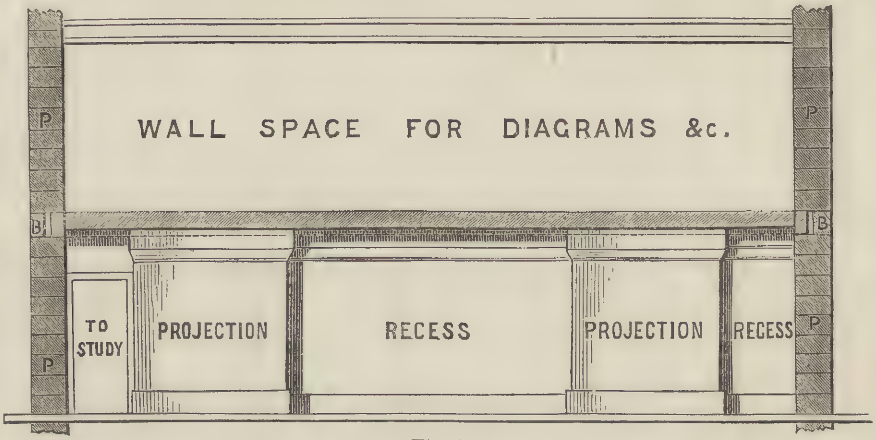


Fig. 8.

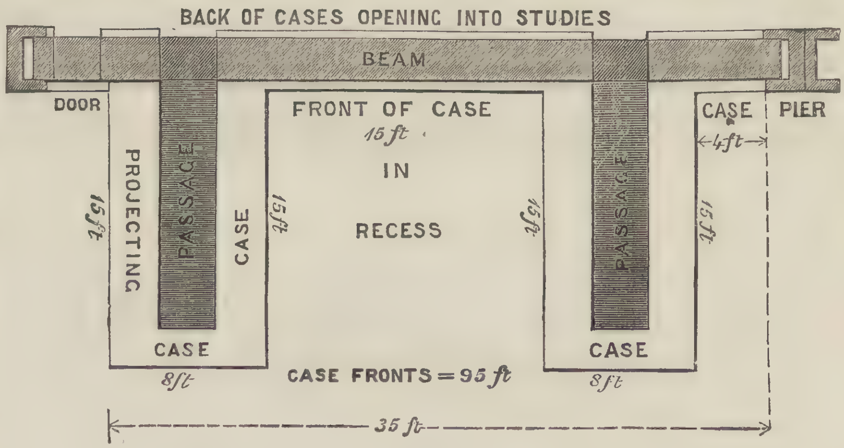


Fig. 9.

General Details of Arrangement.—"Wall-cases" with hermetically sealed glass fronts and back entrances to allow of specimens being removed into the studies, have, from their close association with the subject of construction, been previously described; but it is right to notice the objections that have been raised to this kind of case by Dr. Wallace, with which many other naturalists agree:—

1. They admit of any object being seen by the smallest number of persons at once, so that any one person studying an object almost necessarily monopolises it, and prevents others from approaching it, an inconvenience that reaches its maximum in the recessed cases exhibited in Dr. Sclater's plan.

2. Objects in wall-cases can be seen only on *one* side, which, as *all* sides of natural objects require to be seen, would necessitate many specimens to do the duty of one.

3. The observer on the one side from which alone he can see an object will generally stand in his own light, and will often have distinct vision further impaired by reflection from the glass.

4. When small objects occur alternately with large ones, a great waste of space occurs, and the attention is distracted from the less conspicuous object.

Objection 3 might be obviated by placing two wall-cases to the right and left of a window, and at right angles to it. The wall space then given up to window space might be made up for by placing a narrow floor-case between the two wall-cases. Thus arranged, two wall-cases would stand back to back between each window-pier, on the reduplicated system.

It only remains to note that internal metal fittings must be provided, to allow of the shelves being set at suitable heights, angles, etc., that bars pierced with holes for the reception of small socket-pieces and their clamp-screws, may in many instances be screwed near the fronts of the cases for the reception of small trays adjustable both for distance and angle, and swivel rods for suspending specimens in suitable positions. When the general run of objects in a class is small, "dwarf wall-cases," similar to that shown in Fig. 10, may be advantageously placed around the galleries. The tops of such cases are only as high as the level of the eye when an adult stands erect. The upper part is fitted with shelves six or eight inches wide, adjustable to any angle; the lower part is wider

* Two sets of all the scientific periodicals, reports, etc., would provide for each scientific paper being separated and bound up in separate form, or, if short, with other papers of an allied character on the same class, and deposited in its appropriate class library.

by eighteen inches, forming a shelf that can be looked down on; beneath this it is filled with drawers: the whole of this arrangement can be fitted into the partition that separates gallery from study, so that shelves and drawers are alike accessible from the studies only.

"Floor-cases" (Fig. 13), are very convenient for the display of the vertebrate classes. Such cases should be ten feet long by seven feet high, the width varying according to absolute requirement, if arranged in a manner similar to that recommended for table-cases presently decribed, as in Fig. 14.

To meet special requirements these may be made shorter, so that two cases may be grouped in the same space as a 10-foot case. This allows of scarce specimens—such as the gorilla group in the British Museum—being viewed on all sides; for the same reason one specimen may be made to do the service of two, when both its sides should be examined. Again, in some instances the length may exceed the standard length of ten feet in making provision for the walruses, cetacea, or the height, as for the giraffes. In the new Museum the floor-space of each class gallery must be occupied by specimens belonging to that class, not as at present, corals with mammals, oysters with "oyster catchers" of the avian class, etc., to the utter disregard of that method of silent instruction which may be conveyed through the eye by the proper association of allied species. Such floor-cases must replace the present table-cases, to give cover to new specimens that must replace the mangy cows, and the hippopotamus. These cases must be fitted up with shelves, blocks, suspending rods, etc., according to requirement, to meet the proper height or angle for the most efficient display of objects.

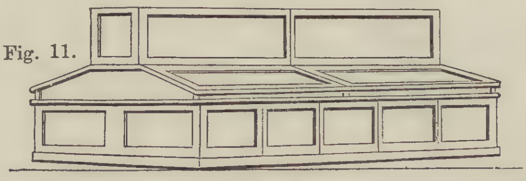


Fig. 11.

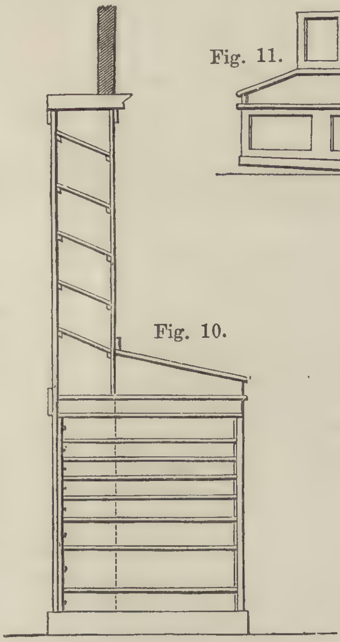


Fig. 10.

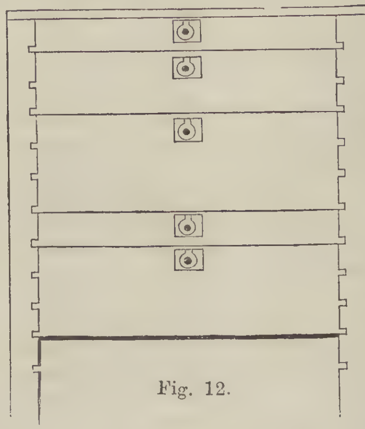


Fig. 12.

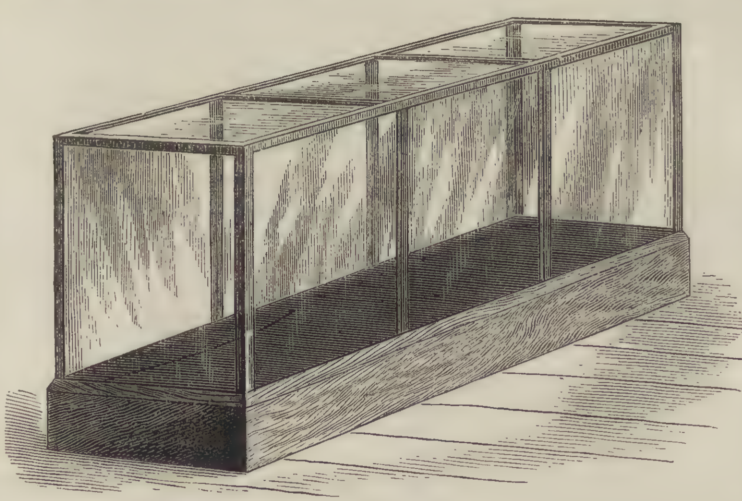
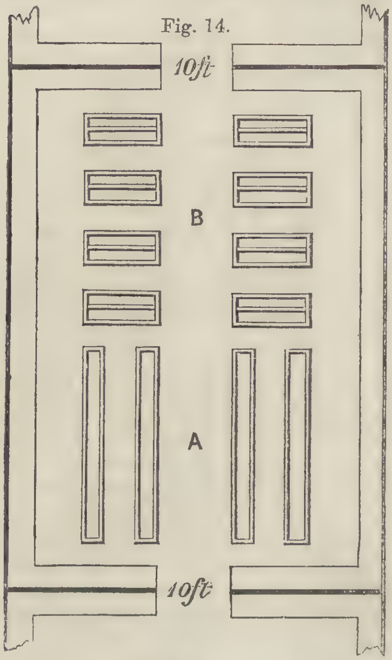


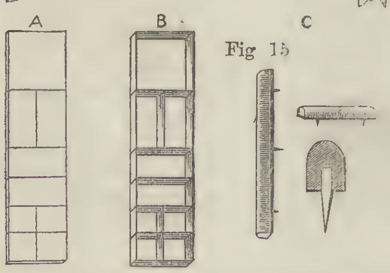
Fig. 13.

"Table-cases" are extremely convenient for the examination of small objects requiring a top light, such as most of the invertebrates, minerals, sections of woods, etc. A good model is shown in Fig. 11, which is 10 feet long by 5 feet 5 inches wide, by 5 feet 10 inches high, filled beneath with drawers.* The upper part may in some instances be replaced with shallow trays, or altogether dispensed with. The best plan for excluding dust from cases that must of necessity be opened at times in a public gallery, and the flap-lids or doors of which are usually permeable, is to line the flat surfaces on which the doors or flaps shut with felt, as this entangles the dust driven inwards by any draught, and if this be combined with a valley-and-ridge fitting the case may be regarded as hermetically sealed. The most convenient way of fitting the drawer space beneath for systematic natural history purposes is to groove the sides at exact intervals of an inch, for the reception of fillets placed on the sides of the drawers, trays, etc., as shown in Fig. 12. The drawers, etc., must be made an inch or the multiple of an inch in depth, so that according to the depth of the largest specimen in any series of objects, a drawer of suitable depth may be selected, to allow such object falling into its exact systematic position, instead of being placed in a supplemental drawer for large objects, as would have to be the case if the drawers were made in the usual way all of one size, or of gradually increasing depths from top to bottom of a tier, which is palpably an unpractical arrangement, as the curator or collector, in classifying his objects, is forced to group large and small specimens in the same drawer, or one drawer may contain shallow specimens, and the next large ones, and if all the drawers were made equal to the depth of the largest object in any given series there would be a palpable loss of cabinet space. By my method, shown in Fig. 12, it will be seen that the curator can "cut his coat according to his cloth," and select drawers according to the exact depth the largest specimens in a group necessitate: thus the first drawer may be one inch deep, the next two inches, the next three inches. Again, having arranged a series of objects, if it becomes necessary to intercalate a fresh group, it is not necessary to re-arrange the entire series of specimens, but simply to remove the drawers below the point where the new group is to be inserted, and to replace the drawers in advanced order. This method applies to drawers, trays, etc., in cabinets, store-cases, table-blocks, and, it will be seen, involves a vast saving of valuable space. I need hardly say it requires good cabinet-work, and strict attention to standard gauges, when in a large series of drawers one may be taken from one part of a room and placed in another block without the drawers sticking, and a certainty that the fronts of the drawers will fit close under each other so as to exclude dust. Agassiz, in a recent Report, calls attention to the loss his museum has recently sustained through the access of moth, etc., to a great

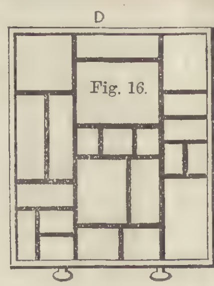
* This is the form adopted at the Liverpool Free Public Museum.

extent due to bad cabinet work; and he says, "It is true, and worth repeating, that the more expensive way of putting up specimens, viz., in good and costly cases or boxes, is in the end the cheapest mode, saving time as well as specimens." If a cabinet of drawers is properly made each drawer should glide in and out without jarring, sticking, etc., even if moved to and fro by one handle only. Great injury may be done to a collection of insects, delicate shells, etc., through bad cabinet-work, as well as by those persons—the terror of curators and collectors—who never learn that a naturalist's drawers should be handled as tenderly as a baby. A whole drawer-full of mounted shells may, by bad handling, be dismounted from their tablet at one shock. Each drawer should be covered with a sheet of glass that drops upon a rebate.





The method of arranging "table-cases" in a gallery is a matter that requires consideration. If placed with their fronts facing a gangway, as shown in A (Fig. 13), it will be seen that those stopping to examine specimens impede the general traffic, and involves mutual discomfort to those stopping and those moving onwards; but if placed with their fronts across the room, with intervals of three to four feet between each case, as shown at B, such arrangement tends to draw off the traffic from the main gangway, and distributes the examining visitors over a gallery out of the way of the passing throng. Table-cases and drawers are usually devoted to objects that require mounting on slabs or in trays. Slabs are made of well-seasoned pine a quarter of an inch thick, and covered on both sides with tinted paper. Extinct species should be mounted on slabs covered with paper tinted to correspond with a geological scale of colours, such as the key to the Geological Survey Maps, or, better still, one formed of the various tinted covering papers cut to represent the relative thickness of strata and arranged in proper sequence, the names, thicknesses, etc., being printed in. Such a geological scale should be hung in every gallery as a key to the tinted papers on which recent and extinct species are fixed. The geographical regions may be indicated by coloured lines placed round the slab, in the same manner as adopted at the International Exhibition, previously described and represented at p. 212, Vol. III., keys for which should also be hung in each gallery. These slabs must be unwarpable. They are cut up in subdivisions of a full-sized gauged tablet, to allow of specimens being grouped, as shown at A (Fig. 15), to economise space and produce an orderly aspect. Trays are made of card or thin wood, and, like the slabs, are made so as to be exact subdivisions of a standard size, as shown by B (Fig. 15). For many years past I have employed a method that allows greater freedom in spacing out specimens than the tray system admits of, for it frequently happens that a specimen is just too large for a tray, so the next size must be taken, with consequent loss of space. My method consists of the employment of long ebonised fillets, fitted with three or more needle points, and short pieces of various lengths fitted with two needle points, shown at C (Fig. 15), so that if a drawer is to be arranged say for minerals, the bottom is first covered with a thick layer of fine cotton wool or velvet, the long slips are then hammered in at equal distances apart, and as each specimen is placed in position, a cross piece is pressed into the drawer bottom, so that each specimen receives the exact amount of space required for its proper display. This system will be understood by the aid of D (Fig. 16), which represents a drawer thus divided.



SEATS OF INDUSTRY.—XXXI.

BRISTOL (*continued*).

BY WILLIAM WATT WEBSTER.

EXTENSIVE improvements were effected in the harbour of Bristol in the first decade of the nineteenth century, by cutting a new channel for the river Avon—the old channel being converted into a graving-dock nearly three miles long, forming several graving-docks—and by enlarging the quay, which has now a length of 2,000 yards, extending along the banks of the Avon and the Frome. These works also included the construction of two capacious basins, the Cumberland and the Bathurst. The floating-dock covers an area of eighty-two acres, and the entire works cost £600,000. After a considerable decrease had taken place in the trade of the port, in consequence of the high rate of the port dues as compared with those of Liverpool, London, and other places, an Act of Parliament was procured in 1848 for transferring the management of the harbour from a company to the corporation, and the change was followed by a reduction of the rates which, combined with the provision of better accommodation, has caused a steady increase in the traffic.

The principal foreign imports of Bristol are sugar, molasses, rum, tea, and cocoa, the next most important being tobacco, timber, wine, brandy, tallow, fruit, wool, hemp, dye-stuffs, oils, saltpetre, and hides. The exports consist chiefly of the various articles manufactured in the city, with salt, iron, coal, and culm, in part the produce of the district. In 1863 the customs duties amounted to £1,150,599, and the total shipping that entered the port consisted of 6,495 vessels, of an aggregate burden of 494,511 tons, of which 1,780 were steamers representing 307,254 tons burden. There belonged to the port in the same year 380 sailing vessels and 41 steamers. Steam communication was established between Bristol and Ireland as early as 1826, and this was the first port in the kingdom that established a regular communication by steam with the United States, the first voyage having been performed by the *Great Western* steam-ship in 1838. This vessel was built at Bristol at a cost of £60,000, and the *Great Britain* and the ill-fated *Demerara* were also "cradled" there, the former costing £120,000. About 400 carpenters are at present employed in the ship-building yards of Bristol. The city has canal communication with the Severn and the Thames, and thence with all England. It is a terminus of the Great Western, of the Bristol and Gloucester, and of the Bristol and Exeter Railways, the former of which was constructed between 1834 and 1838, according to the plans of Isambard Kingdom Brunel, and was the first broad-gauge line in Great Britain. Numerous branch lines connect Bristol with all the principal towns in the west. The most important manufactures of the city are refined sugars, brass and copper wares, soap, glass bottles, crown and flint glass, chain cables, anchors, steam-engines and machinery, tobacco, earthenware, floor-cloth, brass wire pins, patent shot, sheet-lead, zinc, saltpetre, tin pipes, hats, drugs, colours, dyes, starch, bricks, British spirits, malt liquors, and soda. About 1,700 persons are employed at the Great Western cotton works, established in 1840, and the manufacture of woollens, worsted, paper, silk, linen, etc., occupies a large number of persons. Many of the iron foundries in the neighbourhood are on an extensive scale, and they

are increasing both in number and in size. Coal is found in abundance in the neighbourhood of Bristol, and large supplies are obtained from collieries in Gloucestershire.

During the latter half of the last century the population of Bristol would seem to have declined considerably, as the city, including the parish of Bedminster, only contained 66,922 inhabitants in 1801; in 1811 its population numbered 76,952; and in 1821, 95,758. Bristol proper had a population of 65,781 in 1851, but its suburban districts contained 116,094 inhabitants, giving a total population of 181,875. Within the municipal boundaries in that year there were 137,328 inhabitants. The parliamentary borough, which is conterminous with the municipal, extends over 4,674 acres, and in 1861 it comprised 23,590 houses inhabited by a population of 154,093, which, according to the census of 1871, have respectively increased to 27,547 houses and 182,527 inhabitants. Bristol has regularly returned two representatives to Parliament since the electoral franchise was first conferred on the city by Edward I., and the municipal government is vested in a mayor, sixteen aldermen, forty-eight town councillors, a Lord Lieutenant and Lord High Steward. The city is situated on the banks of the rivers Avon and Frome, about eight miles from the point where those rivers debouch into the Bristol Channel, and is on the borders of Gloucestershire and Somersetshire. It extends over seven hills and their intermediate valleys, and is surrounded by a beautiful and fertile district. A few ancient houses, constructed of wood and plaster, with the upper storeys projecting over narrow streets, are still to be found in the older quarters of the town near the river-side, but the greater part of the city consists of spacious streets and squares lined with well-built and substantial houses. Bristol is exceedingly rich in ecclesiastical antiquities. The remains of Roman encampments are to be seen at Clifton and Leigh, and traces of Druidical edifices have been discovered at Stoke and Stanton Drew. The interior of the venerable Cathedral in College Green has lately been restored, and its carvings and fittings renovated. Where the bishop's throne now stands, Bishop Butler, the author of the "Analogy," lies buried. Among the ancient monuments in Bristol Cathedral, the most interesting are those of Robert Fitzhardinge, and certain abbots, bishops, and crusaders; and among the modern, are Bacon's monument to Mrs. Draper (Sterne's "Eliza"), one to Lady Hesketh, the friend of Cowper, a monument to Southey by Bailey, and a fine figure of Charity by Chantrey. The elaborate Gothic gateway at the western end is considered the finest in England. St. Mary Redcliff, on the summit of a hill of the same name, is one of the best specimens of Gothic architecture in the kingdom. It contains several interesting brasses and monuments to Canynge and Admiral Penn, the father of the founder of Pennsylvania, and others, and its muniment room has been made famous in connection with the forgeries of Chatterton, "the marvellous boy" having alleged that he found the Rowley Poems and papers there. The altar-piece of this church was painted by Hogarth. There are forty-four places of worship in connection with the Church of England in Bristol, but the Dissenters are both numerous and influential: the Wesleyan communities have twenty-five chapels, the Independents about twenty, and other sects about thirty-five. Among the celebrated natives of Bristol are numbered William of Worcester the topographer, William Canynge, Sebastian Cabot, Edward Colston, Sir Wm. Draper, Thomas Chatterton, Robert Southey, Sir Thomas Lawrence the painter, Edward Hodges Bailey the sculptor; and the celebrities connected with the city include Samuel Taylor Coleridge, Robert Hall, and Sydney Smith, who was a Canon of Bristol Cathedral.

TECHNICAL DRAWING.—LXXVI.

DRAWING FOR CABINET-MAKERS.

LINEAR DRAWING.

In order that the student may be able to represent or design furniture or any other objects, he must carefully study the numerous and ever-varying combinations of lines, the geometrical methods of constructing rapidly and correctly the various forms required, and the system by which one view is projected from another, or from given dimensions.

These are some of the branches comprehended under the term "Linear Drawing;" and the object of the present course of lessons is to show their immediate application to the work of the cabinet-maker, whose peculiar work is the construction of furniture, etc.

The construction of the geometrical figures is fully demonstrated in "Practical Geometry applied to Linear Drawing," page 63, Vol. I. of The Technical Educator, and hence only such will be added as may be required for the immediate

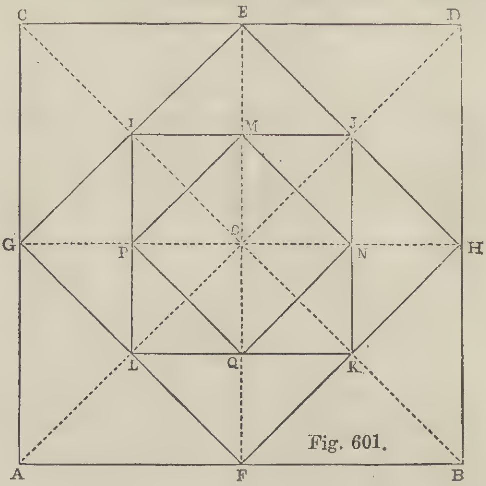


Fig. 601.

subject of any particular lesson. The student is therefore urged to work attentively through the lessons referred to, forming as they do the stepping-stones to all special branches of geometrical drawing.

The general principles of construction in wood, the methods of lengthening timber and joining boards, etc., have been given with numerous illustrations in "Drawing for Carpenters and Joiners;" and therefore these are not here repeated, in order

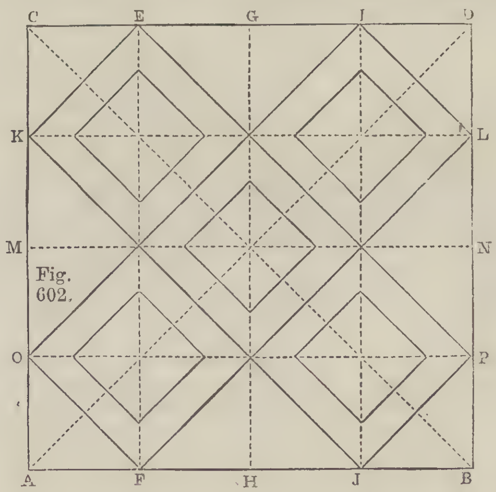


Fig. 602.

that special attention may be given to the Perspective of Furniture and Freehand Drawing, adapted to the present branch of industry.

The subject of this lesson is given with the view of affording the student practice in accurate combination of straight lines; and the forms are such as will at once show any imperfections, thus enabling the student to test his work as he goes on. These forms are in appearance very simple, but they are important, since, in the refinement required in the delineation of furniture, a single line out of place, be it ever so little, is liable to injure the entire drawing. The truth of this will be often exemplified as our lessons progress.

Fig. 601.—Construct the square A B D C. Draw diagonals A D and B C. Draw the lines E F and G H through the inter-

section (o) of the diagonals. Join F G, G E, E H, H F, thus constructing a square within A B C D.

The diagonals pass through the sides of this inner square in I J K L. Join these points, and another square parallel to the original one will be formed.

The lines E F, G H, cut through the sides of this square in M N Q P, and these points being joined, a fourth square will be formed, the sides of which will be parallel to F G E H.

The cabinet-maker, who is constantly called upon to cut numerous pieces of veneer into accurate forms, will find useful practice in this figure by drawing it on thick paper or card-board, and cutting it according to the lines. If correctly worked, the triangles G C E, E D H, H B F, and G A F should be equal to each other, and also to the four triangles G O E, E O H, H O F, and F O G. Consequently, these four triangles when placed together should form a square equal to F G E H.

Similarly, the triangles L G I, I E J, J H K, and K F L, are together equal to the square I J K L, and this same system will apply to the inner square.

Fig. 602.—This is another study of the same character as the last.

Draw the outer square A B D C, and divide it into sixteen equal squares by the lines E F, G H, I J, K L, M N, O P.

Join E P, K J, K E, and P J. Then the rectangle K E P J will consist of three equal squares placed upon and parallel to the diagonal B C. Again, join I O, F L, O F, and I L, and a similar rectangle parallel to the diagonal A D will be formed.

The inserted figure will then consist of four equal squares surrounding a fifth. The squares within these are drawn parallel to the others.

Fig. 603.—We now proceed to the delineation of a simple article of school furniture—viz., a master's pedestal table, with cupboard and drawers; and take the elevation facing the room first, being the simpler. The scale is ¾ inch to the foot.

Draw the ground-line, and the rostrum or platform on which the table stands. This platform is 9 inches high, and extends 1 foot on each side of the plinth of the table.

The body of the table is 4′ 6″ across, the plinth projecting ¾ inch all round, and the total height is 2′ 6″, out of which the thickness of the top occupies 1 inch, projecting 1½ inch on each side.

The front here presented is formed of three panels, the framing of which is 4 inches wide.

Proceed now to draw the plinth, commencing with the perpendiculars *a b*, and the horizontal *c d*. Next draw the perpendiculars *e f* at ¾ inch on each side within *a c* and *b d*, and then complete the general outline by drawing the top.

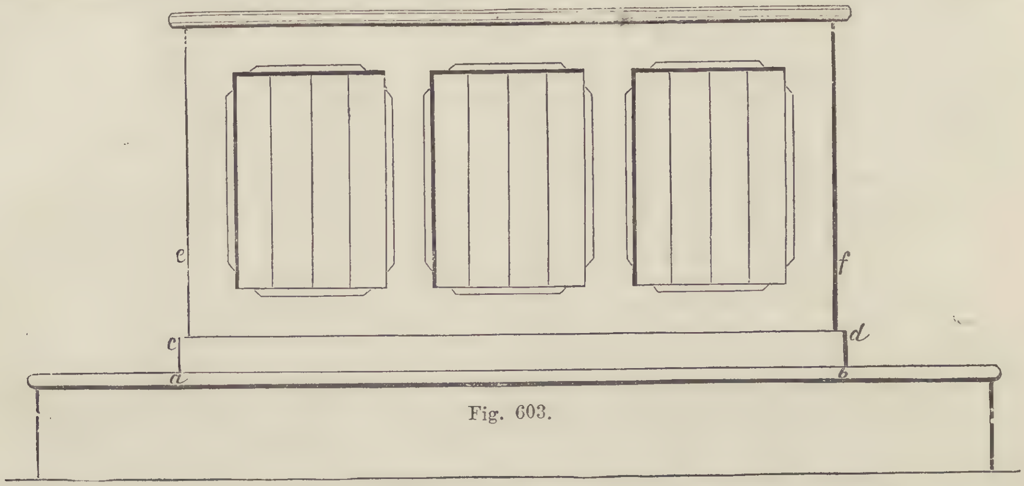


Fig. 603.

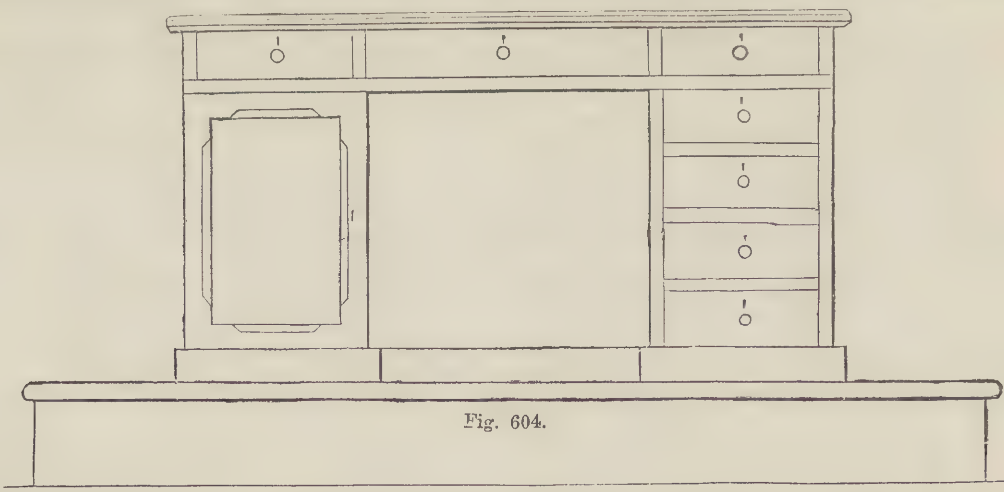


Fig. 604.

Draw the rectangles for the panels, the framing being 4 inches wide, chamfered at the edges up to 2 inches from the angles. This has the effect of lightening the appearance. The panels are made up of separate boards, the edges of which also are chamfered at their juncture, but too slightly to be shown in this illustration.

Fig. 604 is the true front of the same table, showing the pedestals, which are 1′ 3″ wide; the one contains a closet, and the other four drawers. The top of the table also contains three drawers, and is with the plate 6 inches deep. The general measurements are of course the same as in the other elevation, and the method of drawing this subject is precisely similar.

MINING AND QUARRYING.—XXVII.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

SHEET LEAD—PIPING—ADHESION OF LEAD AND TIN—ALLOYS—SHOT-MAKING—MASSICOT AND LITHARGE—PROPERTIES OF LITHARGE—REDUCTION OF LITHARGE—PEROXIDE OF LEAD.

THE large sheets of lead which are in such extensive use by plumbers for roofing and the making of water-tanks, are made in the following manner :—The pig lead is melted and cast in a rectangular mould, so as to form a large block of that shape, after which it is rolled out to the desired thickness. The first thing necessary for this purpose is a melting pot, large enough to contain eight or nine tons of lead at a time. The pot, A, Fig. 1, is made of iron, and hemispherical in form, having a pipe, B, issuing from the lower part of it, by which the molten metal is drawn off. Below the melting pot is a fire-grate, C; and before the lead is thrown in, the iron pot is heated up to redness; the charge is then introduced, and an iron hood, D, Fig. 2, which is suspended over the pot, and can be raised or lowered at pleasure, is let down upon it. The hood serves the double purpose of preventing the heat from being dissipated, and also the escape into the workshop of the hot gases from the melting lead, which would be injurious to the health of the workmen: these are carried off through a telescope pipe, E, Fig. 2, in the top, which is connected with the flue. The heat from the red-hot iron of the pot will be sufficient to melt the lead without keeping up the fire below, and it is not desirable to heat it beyond this point, or greater loss of metal will occur. When the lead is all melted it is skimmed, and then drawn off into the mould by the removal of an iron plug, F, in the pipe. The mould is entirely made of iron, the four sides being strongly bolted together and to the bottom plate, G. It is usually 6 or 7 feet across from side to side, and 8 or 9 inches deep. The bottom plate of the mould should be slightly concave in the centre, which will compensate the slight sinking of the surface in the middle of the casting during the process of cooling. Some care is necessary in letting the lead flow into the mould, as it comes out with great force, and is liable even, unless checked, to carry away the sides. Immediately the mould is filled, a wooden bar of the exact width of the mould is drawn over the surface of the liquid metal to remove all impurities, and this is repeated as often as may be necessary to keep the surface quite bright during the cooling. As soon as the lead has solidified the sides of the mould are removed, and the great block of lead is lifted off and deposited upon the rolling apparatus. This consists of a pair of very heavy iron rolls about 9 feet long, and nearly 2 feet in diameter, between which it is passed forwards and backwards a great number of times until it is gradually reduced to the required thickness; for this purpose the rolls are from time to time brought nearer and nearer together by means of adjusting screws. A series of wooden rollers on each side, which move freely, support the sheet of lead in a horizontal position while passing to and fro. The lead is generally slightly warm when the rolling commences, but that is not necessary to the success of the operation, and it is practically rolled cold.

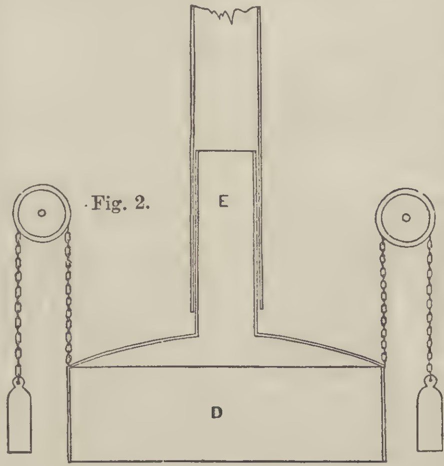


Fig. 2.

In addition to its domestic uses, which are sufficiently familiar, a considerable quantity of sheet lead, and that of the finest quality, is used in the construction of sulphuric acid chambers, as it is one of the few articles not affected by the oil of vitriol. Some idea of the quantity required for this purpose will be gathered from the article on sulphuric acid, in the series on "Chemistry applied to the Arts."

In lead pipes the soft desilverised lead is considered best, as it resists a greater pressure from within than the inferior qualities will; but many plumbers have a fancy for piping made of a harder metal, as the latter will better retain its circular form, and is therefore more easily manipulated. Antimony is even added purposely sometimes, for the sake of satisfying those who wish a hard pipe, though in other respects it is certainly not improved thereby. The lead is forced by great pressure through perforated dies corresponding to the respective sections of piping that may be desired, in the same way that the circular clay drainage pipes are made; by this means perfect uniformity will be secured throughout its whole length, and no seams will be required.

This operation is suggestive of one peculiar property of lead not hitherto mentioned, viz., that if the surfaces are thoroughly clean and bright, two pieces of lead can be perfectly united by mere pressure. In the same way, precipitated lead in the state of a fine powder may be compressed into a solid mass.

Tin-foil can be made to adhere to sheet lead in the same effectual manner by passing the two metals under heavy rollers; and this fact has been taken advantage of in the manufacture of the so-called patent metallic capsules, which are now very commonly used for protecting the corks of bottles.

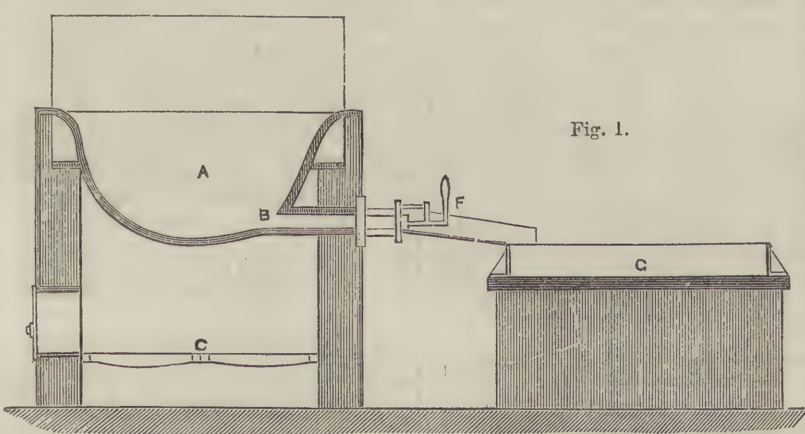


Fig. 1.

Lead forms some alloys with other metals which are of value in the arts. Those with tin, forming solder of different kinds, have already been described; others will be treated subsequently under the headings of the respective metals with which the lead combines; but there is one compound of which lead is the chief ingredient, which forms an article of very much greater commercial importance than most persons would readily imagine. We refer to what is commonly known as shot metal.

Pure lead will not answer the purpose of the maker of small shot. In order to enable it to take a strictly spherical form, it has to be combined with a certain quantity of arsenic. The arsenide of lead, though harder than the pure metal when cold, is very liquid when melted, so as greatly to resemble mercury, the readiness of which to separate into small round globules is so well known. If the lead is of soft quality, about 0·3 per cent. of arsenic will suffice; but for a hard lead about 1 per cent. will be necessary. To ascertain when the lead has taken up the precise quantity required to make a good alloy requires

some little experience on the part of the manufacturer. The lead, to the quantity of two or three tons, is melted in a pot, and then the surface of the metal is strewn with a little powdered charcoal, immediately after which the arsenic, either in the form of arsenious acid or orpiment (the sulphide), is added, and briskly stirred in with the metal. The pot is then covered up, and after two or three hours the arsenic is reduced to the metallic state, and has entered into combination with the lead. During this process a good deal of the arsenic is unavoidably lost, so that even when dealing with good lead it is usual to add about 1 per cent. On uncovering the pot the surface of the metal will be found covered with a coating of oxide, which contains a considerable proportion of arsenic. To ascertain whether a suitable alloy has been formed, a little of the metal is taken out and allowed to fall through a perforated plate into water. The form presented by the grains will indicate whether there is a sufficiency or otherwise of arsenic, the composition which contains a right proportion of this substance yielding particles of a strictly spherical shape.

A satisfactory test having been attained, the metal is run into small ingots ready to be converted into shot. These ingots, for future use, are raised to the top of the shot tower, which should be upwards of 150 feet in height, and here they are remelted when required. The perforated frames, or cullenders, through which the molten metal has to pass, are kept hot by being surrounded with a charcoal fire, and the surface of the frames is dressed with a little oxide, which has the effect of allowing the metal to pass freely through the perforations without adhering to the edges. The apertures vary in size from 1-50th to 1-360th of an inch for the sizes known as numbers 0 to 9; but these will not be found to correspond with the size of the shot produced, which is always considerably larger than the perforation through which the metal has passed, as it widens out into the spherical form in falling. The smaller sizes are allowed to fall about 100 feet, but the larger about 150. At some of the shot towers on the Continent provision is made for a much greater fall than even this. At the bottom of the tower is a well filled with water to the depth of 5 or 6 feet, which receives the shot.

The desired quantity having thus been made, the shot is put upon a stove to dry. A perforated cylinder is then filled with the shot, and made to revolve. The first series of holes in the cylinder correspond to the smallest shot, and underneath this part is a box to receive the grains as they pass through. The larger sizes follow in succession, with their corresponding receptacles, so that by the revolution of the cylinder the whole mass of shot is separated into the various sizes required in the trade. The bright surface is afterwards given to the shot by their being agitated for some time in a vessel containing a small quantity of blacklead. The defective grains have yet to be separated, which is done by allowing all the shot to roll down a table which is very slightly inclined. Those which are truly spherical will run with a straight course to the receptacle at the lower end, but the defective ones will gradually find their way to the sides, where they are collected and put apart for remelting.

There are several salts of lead which are of importance in the arts. The oxide (protoxide, PbO) has already been referred to as one of the compounds produced in the course of smelting; but it will be more especially so when we come to speak of the separation of silver from lead, which will be described under the head of the more valuable metal. This compound is known both by the name of massicot and litharge, according to its colour, the former being more decidedly yellow than the latter. The chemical constitution appears to be the same in both cases, and the reddish tinge which litharge possesses is probably due to some difference in the molecular arrangement of the particles. It is a better article for ordinary purposes, as it is more stable than massicot, and resists better the action of the atmosphere. It is used as a pigment, and by the manufacturers of glass and earthenware. To the metallurgist it possesses properties of considerable value, as it forms fusible compounds with some of the metallic oxides which are infusible by themselves, and thus enables them to be readily separated from others. Those of copper and antimony are rendered fusible by a very small addition of litharge; those of tin, zinc, iron, titanium, manganese, and arsenic require a somewhat larger proportion. Sulphur is converted into sulphurous acid on heating it with an excess of litharge.

Notwithstanding the various useful purposes to which this oxide may be put, the quantity which is necessarily produced in the final processes for the separation of lead from silver, by cupellation, is so much in excess of what is required in trade, that the litharge has again to be reduced to the metallic state.

In many parts of the Continent this is done in blast furnaces; but in England preference is given to a large reverberatory furnace of ordinary construction, having a tap-hole at the lower end or side of the sole, with a pipe communicating with the receiving pot outside. The tap-hole should be protected by a dam of clay, over which the lead, when it has accumulated sufficiently, will run, the dam being only removed to draw off the remainder of the lead at the end of the operation, when the whole of the metal in the charge has been reduced. The work commences by raising the furnace to a red heat, and then throwing in a quantity of small coal of a quality which will leave but little ash. This must be spread evenly over the sole of the furnace to the depth of two or three inches. When the coal has thoroughly united, the litharge, mixed with some more small coal, is thrown in until the furnace is as full as convenient. The oxygen contained in the litharge combines with the carbon of the coal, and is evolved as carbonic acid, leaving the lead free, which is soon found to be flowing towards the bottom of the hearth. In a hour or two so much lead will have accumulated, that it will begin to flow over the dam into the receiving pot. For the next six hours fresh supplies of litharge and small coal are thrown in to keep the furnace full, and as the lead continues to flow into the pot, it is lifted out with ladles and poured into the pig moulds to cool. When the lead ceases to flow from the furnace, the dam is broken down, a greater heat is got up, and the residue well rabbled in order to separate the lead that will be mechanically mixed with the cinder, which should consist of little else than the ash from the coal. If the litharge, however, is impure, and contains the oxides of some of the other metals not uncommon in lead, some quantity of slag will be left at the close of the operation.

The peroxide of lead, PbO_2, acts the part of an acid in combining with the alkalies, calcium, barium, and other bases; but its principal use is in the manufacture of lucifer matches, in which considerable quantities are now employed. It may be conveniently made by boiling the acetate of lead in an excess of hypochlorite of lime solution, until the odour of acetic acid takes the place of that of the chlorine, when the whole of the lead in the acetate will be converted into the peroxide. The product has then only to be thoroughly washed. It can also be made by gently heating litharge with a mixture of the chlorate and nitrate of potash, care being taken to keep the temperature low, or minium, instead of the peroxide, will be the result.

NOTABLE INVENTIONS AND INVENTORS.

XXXII.—SIR SAMUEL MORLAND.

BY JOHN TIMBS.

Sir Samuel Morland, although born just upon two centuries and a half since, must not be left among forgotten inventors. He is entitled to special regard, for the glimpses which his mechanical inventions afford us of the science of the period, apart from his personal history, which is interesting. He was the son of the Rev. Thomas Morland, of Subhamstead-Bannister, near Reading, in Berkshire, and was born about the year 1625. He was educated at Winchester and Cambridge. He remained at the university for ten years, but never took a degree. Soon after leaving college, we find him sent on the famous embassy to the Queen of Sweden, in company with Whitelocke and a retinue of other gentlemen. Whitelocke, in his Journal, calls him "a very civil man, and an excellent scholar." On his return, Morland became assistant to Thurloe, the secretary to Oliver Cromwell. He is said to have been privy to the plot usually known as Sir Richard Willis's Plot. In his chambers at Lincoln's Inn, Thurloe is reported to have discussed with Cromwell Willis's plot for seizing Charles II., early in 1659. In the same room sat Thurloe's assistant, young Morland, at his desk, apparently asleep, and whom Cromwell would have dispatched with his sword, had not Thurloe assured him that Morland had sat up two nights, and was certainly fast asleep.

He, however, divulged the plot to the king, and thus saved Charles's life. Birch relates the story in his Life of Thurloe; but it is not considered supported by proper evidence. Echard, in his History of England, produces a letter from Morland to Willis, dated March 10th, 1660, in which he expressly denies the above statement; but Morland's own testimony, in his Autobiography, is to the contrary; if he did write it at all, it was probably intended merely as a means of protection from the wrath of Sir Richard Willis.

Morland had already shown his genius for mechanical science. On the restoration of Charles he was made Master of Mechanics to His Majesty, who soon afterwards made him a gentleman of His Majesty's privy chamber.

It is now time to speak of his writings and mechanical inventions. From some correspondence between Morland and Dr. John Bell, it appears that Sir Samuel, as early as 1666, had intended to publish a work on the Quadrature of Curvilinear Spaces, and had actually proceeded to print a portion of it, when, by the advice of the latter, he was persuaded to lay it aside altogether. Morland not only yielded implicitly, but, in a letter written shortly afterwards, he furnishes arguments against some propositions of his own treatise. "I should desire," says he to Bell, "to bee altogether mute, and to submitt to your judgement in all things." Bell, in another place, informs us that two sheets of the work were actually printed.

It was about this time that Morland invented his arithmetical machine, which he mentions in a letter dated May 13th, 1666. He did not, however, publish an account of it before the year 1673, when, "by the importunity of his very good friends," it was made public. The little work in which it is described is illustrated with twelve plates, in which the different parts of the machine are exhibited. Its operations are conducted by means of dial-plates and small indices, movable with a steel pin. By these means the four fundamental rules of arithmetic are very readily worked, and to use the author's words, "without charging the memory, disturbing the mind, or exposing the operations to any uncertainty." His "Perpetual Almanack" is given at the end, which was often printed separately. One copy of Morland's little book, long in the possession of Professor Davies of Woolwich, contains a very beautiful portrait of the author, but with this exception, we have never seen an exemplar so distinguished.

The invention of the speaking trumpet in its present form is attributed to Morland, though it is warmly contested for Athanasius Kircher. The ancient contrivances of this kind resembled hearing rather than speaking trumpets. Some have considered the great horn described in an old manuscript in the Vatican Library, as having been used by Alexander the Great to assemble his army, to be the oldest speaking-trumpet on record; but the description does not state that Alexander *spoke* through the horn. Morland published the account of his useful instrument at London, in 1671, under the title of "A Description of the Tuba Stentorophonica, an instrument of excellent use, as well by sea as by land." In this rare tract, consisting of eight pages, he gives an account of the various experiments that he made before his instrument had attained a certain degree of perfection. The first trumpet that he constructed, "although," says Sir Samuel, "the invention had been long before digested in my thoughts," was made in glass in the year 1670, being about 2 feet 2 inches in length, the diameter of the greater end 11 inches, and that of the other end $2\frac{1}{2}$ inches. "With this," he says, "I was heard speaking at a considerable distance by several persons, and found that it did very considerably multiply the voice." The next he made was of brass, about $4\frac{1}{2}$ feet long, 12 inches in diameter at the large end, and only 2 inches at the small end, to which was affixed a mouthpiece, "made somewhat after the manner of bellows," to move with the mouth, and thereby prevent the escape of the breath. This was tried in St. James's Park, and rendered the voice audible at a distance of nearly half a mile. The third instrument was of copper, recurved in the form of a common trumpet; its total length was 16 feet 8 inches, the large end 19 inches and the small end 2 inches in diameter; with this the voice was heard about a mile and a half. After giving a description of some experiments with other trumpets, he enters into a philosophical description of the nature of sound, and the best form of speaking trumpet, which he leaves doubtful, and concludes with "an account of the manifold uses" of his instrument, which are very excusably exaggerated. He appears to have overrated the power of his trumpet, for, in his "Urim of Conscience," he says that he has no doubt but that it might be improved so as to carry the voice for the distance of ten miles. Yet Dr. Young records that at Gibraltar the human voice has been heard at a distance of ten miles. With the largest of Morland's trumpets, tried at Deal Castle, the voice was conducted a distance of between two and three miles over the sea. An advertisement prefixed to a French translation of Morland's treatise, published in London in 1671, states that Morland's tubes were sold by Moses Pitt, a bookseller in St. Paul's Churchyard, at the price of £2 5s. There is one of Morland's original trumpets, about six feet long, now preserved in Trinity College Library, Cambridge. It is in bad condition, and no one knew what it was till our time, when it was identified by a member of the college.

The invention excited such general interest at the time, as to make Butler say in "Hudibras:"—

> "I heard a formidable voice,
> Loud as the stentophonic noise."

The invention of the fire-engine has been claimed for Morland; but he was rather an improver than the inventor of that machine, which originated with Ctesibius, a distinguished Greek mechanician, who lived in the reign of Ptolemy Philadelphus. Hero, a pupil of Ctesibius, describes a sort of forcing pump with two cylinders, employed for extinguishing fires. Apollodorus, architect to the Emperor Trajan, has left a description of a machine consisting of leathern bottles, with pipes attached to them; when the bottle was squeezed, a jet of water flowed through the pipe, and was thus used to extinguish fires. Beckmann found, in the accounts of many of the German towns, entries for the cost of such machines: thus, in the accounts for the building of Augsburg for 1518, fire-engines are mentioned under the name of "instruments of fire," or "water-syringes." As early as 1590, Cyprian Lucar described a rude fire-engine, or squirt, which acted precisely on the principle of that instrument; Evelyn also mentions a fire-engine invented by Greatorex in 1656, which was ten years before he saw the "quench-fires" of Morland. In the vestry of the church of St. Dionis Backchurch, Fenchurch Street, London, are preserved four large syringes, which were formerly used for the extinction of fires; they are about 2 feet 2 inches long, and were attached by straps to the bodies of the firemen. At the present day a species of squirt is used among Oriental nations to extinguish fires. An old engraving purports that John Lofting, a merchant of London, was the inventor and patentee of the fire-engine; in one corner is represented the Monument, and in another the Royal Exchange; the engines are represented at work.

The principal objects of Morland's study were, however, water-engines, pumps, etc., which he carried to a high degree of perfection; his pumps brought water from Blackmore Park, near Winkfield, to the top of Windsor Castle. In 1675 he obtained a patent "for certain pumps and water-engines by him invented." In 1697, two years after his death, a tract by Sir Samuel was published at the expense of his son. It is entitled "Hydrostatics, or Instructions concerning Waterworks," and contains an account of his various methods of raising water, besides tables of square and cube roots. From the close of Joseph Morland's preface it appears that many of his father's works were left unpublished. There is also a treatise by Sir Samuel, in the Harleian collection of MSS., which is entitled "Élévation des Eaux, par toute sorte de Machines, reduite à la mesure, au poids, et à la balance. Présentée à sa Majesté très Chrétienne, 1683." At page 25 commences a very short tract on the steam-engine, entitled "The Principles of the New Force of Fire, invented by Chev. Morland in 1682, and presented to His most Christian Majesty, 1683," and these principles are explained as follows:—

"Water being converted into vapour by the force of fire, these vapours shortly require a larger space (about 2,000 times) than the water before occupied, and rather than be constantly confined, would split a cannon; but being duly regulated according to the rules of statics, and by science reduced to measure, weight, and balance, then they bear their load peacefully (like good horses), and thus become of great use to mankind, particularly for raising water, according to the following table, which shows the number of pounds that may be raised 1,800

times per hour to a height of 6 inches, by cylinders half filled with water, as well as the different diameters and depths of the said cylinders." Then follows his table of the depths of different sized cylinders. This evidently indicates a perfect knowledge of the subject; and, to his great credit also, let it not be forgotten that he has correctly stated the increase of volume which water occupies in a state of vapour, which must have been the result of experiment. His researches, however, seem to have had little influence on the progress of the practical application of steam (*Penny Cyclopædia*). It should be added that Morland does not indicate the form of the machine by which he proposed to render the force of steam a useful mover. It is, however, remarkable that at this early period, before experiments had been made on the expansion which water undergoes in evaporation, Morland should have given so near an approximation to the actual amount of that expansion. It can scarcely be supposed that such an estimate could be obtained by him otherwise than by experiments.

Among Morland's written works, according to Beughem, in his "Bibliographica Britannica," are "Articles and Rules for the better government of His Majesty's Forces by Land and Sea, during this present War." His "Doctrine of Interest, both Simple and Compound," published in 1679, has the tables very accurately calculated; but his "New Rule for the Equation of Payments" is erroneous. Another tract by Morland, consisting of four leaves, and entitled "The Count of Pagau's Method of Delineating all manner of Fortifications (Regular and Irregular) from the exterior Poligone, reduced to English Measure," etc., was published in 1672. The "Urim of Conscience," already mentioned, was written during Morland's blindness, and is a very singular piece of composition; it contains reflections on the fallen state and insignificance of man, and the uncertainty of life. Morland is said to have written a treatise on the barometer, which was answered by Lord North in another tract on the same subject. He is also said to have invented the capstan to heave up anchors; but he must be considered rather as an improver than the inventor of that machine. The same remark will apply to various other performances which have been elsewhere attributed to him.

Of more popular interest are the minor inventions of Morland, of which his abodes bore traces almost unto our time. Lysons, upon the authority of an enrolment in the Duchy of Cornwall Office, states that Sir Samuel Morland, in 1675, "obtained a lease of Vauxhall House, made it his residence, and considerably improved the premises." Aubrey tells us that some years before, Morland had built "a fine room at Vauxhall, anno 1667, the inside all of looking-glass, and fountains very pleasant to behold, which is much visited by strangers; it stands in the middle of the garden." And Mr. Bray, the historian of Surrey, was informed by one of the proprietors of Vauxhall Gardens, in 1813, of a circumstance which shows that the dwelling-house then connected with the garden once belonged to Sir Samuel Morland. From the back kitchen of the house a lead pump was removed, about 1794, bearing the mark—S.M. 1694. The room mentioned by Aubrey as having been erected by Morland, is believed to have stood where the orchestra was afterwards built; and grave old Mr. Bray hints at the probability of a room having been erected by Sir Samuel for the reception of Charles II., when he visited this place with his ladies. In the above house and grounds Morland formed a large collection of mechanical contrivances. He received his baronetcy in 1660, and subsequently had a pension of £400 settled upon him; but embarrassments in his affairs, owing to an imprudent marriage, obliged him to dispose of the house at Vauxhall. He afterwards removed to a house at Hammersmith, near the water-side, where he died December 30th of the following year (1695). Poverty and loss of sight compelled him to rely almost solely on the charity of Archbishop Tenison. In a letter dated March 5th, 1694, he returns him thanks for his kindness, "which was far greater," says Sir Samuel, "than such a poor wretch as I could ever hope for." This letter, written when he was blind, is a very curious relic, and is now preserved in the library at Lambeth Palace. John Evelyn, in his Diary, describes Morland when suffering under this accumulated load of misfortunes:—"25th October, 1695.—The Archbishop [Tenison] and myself went to Hammersmith, to visit Sir Samuel Morland, who was entirely blind, a very mortifying sight. He showed us his invention of writing, which was very ingenious, also his wooden calendar, which instructed him all by feeling, and other pretty and useful inventions of mills, pumps, etc.; and the pump he had erected that serves to water his garden, and to passengers, with an inscription, and brings from the filthy part of the Thames near it a most perfect and pure water. He had newly buried £200 worth of music-books, being, as he said, love-songs and vanity. He plays himself psalms and religious hymns on the theorbo." The inscription to which Evelyn refers is on a stone tablet fixed in the wall, and is as follows:—"Sir Samuel Morland's Well, the use of which he freely gives to all persons; hoping that none who shall come after him will adventure to incur God's displeasure by denying a cup of cold water (provided at another's cost, and not their own) to either neighbour, stranger, passenger, or poor thirsty beggar. July 8, 1695."

Morland constructed for himself a coach, with a movable kitchen in it, so fitted with clockwork machinery that he could broil steaks, roast a joint of meat, and make soup as he travelled along the road. The side-table in his dining-room was furnished with a large fountain of water; and every part of his house bore evidence of his ingenuity.

CAPITAL AND LABOUR.—III.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

THE WAGES OF LABOUR.

We have seen from the statements made in the preceding chapters that the true profits of capital are only wages under another name, and that these wages are due to the employer, because he superintends and directs other labour which is inferior or subordinate to his own. It is plain also that any contest between capitalist and labourer which has for its object—as either of the parties provokes or continues the contest—the advantage of one side at the expense of the other, is really a struggle between two classes of labourers, and that such a struggle could not occur except it were in the distribution of a stock or quantity, the several claimants of which base their demands on strictly analogous work. The amount of rent paid by an occupier of land, the rate of interest paid by a borrower, are not and cannot be objects of dispute, for they are settled upon considerations which are purely scientific, and therefore spontaneous in their origin, and precise in their quantity. A strike or a lock-out, in order to lower or heighten rent, to depress or exalt the rate of interest, would be a plain absurdity, to which no rational person would have recourse.

The wages of labour depend, exactly as every other article in value depends, on three causes. One of these is the demand for labour—*i.e.*, not labour in general, but the particular kind of labour. For since man must work in order to subsist, there always must be a demand, and a very energetic demand, for labour in general, or in the abstract. The second cause is the cost which has been incurred in order to produce the labourer—*i.e.*, to make him fit to carry on his work. The third is the probable duration of those powers, to the possession of which the labourer owes his power of producing something useful, and therefore of procuring employment. The labourer whose possession of such powers is temporary will as a rule obtain, relatively speaking, high wages during the time that his power lasts. For instance, I presume that the period in which a professional cricketer keeps his best strength, activity, and speed, is brief. The best-paid juvenile labour is that of a chorister in a cathedral. But the chorister's voice is sure to give way very soon after he has attained the best use of it. Those adults who are engaged in any dangerous or deadly trades, as, for instance, dry grinders, are paid at much higher rates than could be obtained for the skill which they possess, because those who are engaged in such a calling are notoriously short-lived. In short, the human body is a machine, which certainly wears out at some time or another, and may be deprived of those qualities which make it valuable at a very early date. The certain cessation and the possible arrest of those powers are risks of a less or more urgent kind, and must be provided against in just the same way that other risks are, by an extra payment.

At any given time, there may be too much of any given kind of labour in the market seeking for employment. In some callings this excess is chronic. Such is the case with needlewomen, with barristers, and perhaps with clergymen, the causes

of this excess being different. There are few employments open to women, and consequently those which can be followed are constantly overcrowded. The professions of the bar and the church are held in great esteem, and possess great occasional prizes. The first of these facts is practically an equivalent of wages; the second, owing to the natural disposition of mankind towards enterprise, and the general tendency of most persons to overvalue their abilities and their prospects, makes the callings attractive. And here it may be observed that self-esteem, which is odious in the individual, is, as a motive influencing men in the mass, one of the principal causes of social progress.

Sometimes again the cause is transitional. By this I mean that circumstances have arisen which render some kinds of labour unprofitable, and therefore depress the wages of those who ply the industry. At the present time such a state of things undoubtedly characterises the labour of the tailor and the shoemaker. Of late years work which used to be performed by hand is done by machinery. Now it is perfectly true that the substitution of mechanical labour for manual work is a gain to society; the substitution would never have occurred otherwise. A man who makes any process easier—and the motive which leads to the adoption of machinery is the design to make work easier—intends to sell the product of such work more cheaply, because in this way only can he get any advantage of increased sale in the general market. Generally, too, as the mass of society is benefited by the improvement, so the workman is not much harmed, since labour is in demand for the manufacture of the machines, and most industries are not of so rigid and special a kind as to disable the workman from seeking some similar employment. But there are cases where machinery annihilates an industry, or depresses it so seriously as to cause considerable distress to the workman. Such, as I have observed, is the case with the tailor and shoemaker. Similarly, I imagine, the art of photography has put an end to the calling, as a rule, of the miniature painter, and has induced similar effects on that of the engraver.

Lastly, the excess may be temporary. To this excess all callings whatsoever are liable, though in variable degree. In the winter months, the artisans employed in the building trades are ordinarily in excess. When the price of wool or cotton rises so high as to check the use of cloth manufactured from these materials, operatives in these callings are in excess. It is, however, superfluous to illustrate this kind of fact, for anybody who has had any experience whatever of social life could supply himself with instances.

We have thus been able to account for two of the causes which determine the rate of wages. These are the demand for the labour which the workman brings into the market, and the duration of those powers on which the value of labour depends. The remaining cause, the cost of producing the labourer, to which may be added the cost of maintaining the labourer, is, when the two other causes are accounted for, permanent, and governed by an invariable law. The law is, *If two persons of equal, or nearly equal natural capacity, are able to supply some labour which is in demand, the wages which each person will receive will be determined by the cost incurred in supplying the labourer, together with the charge which is necessary in order to enable the labourer to carry on his avocation.* To this law there is no exception.

My reader will see why I have used the expression, "of equal, or nearly equal capacity." There is, I am aware, an opinion that, in many callings at least, the capacities of men are equal, and that real differences in effectiveness are due to the fact that the ablest person has had the best education. If this be true, the case is covered by my definition, for greater cost has been incurred in preparing the individual for his calling. But if, as is certainly the case in some callings, and probably is in all, there are great differences of natural capacity or quickness, it is necessary to take account of such capacity, just as one does of the fertility which attaches to a particular field, or more notably still to some site for business premises. In some callings, natural capacity or genius is undeniably the primary cause of success, or, in economical language, of value. For example, the most mysterious of all natural gifts, that of the construction of music, has been developed at so early an age, and in so marked a manner, that no education can explain the phenomenon. It would be absurd to assign the genius of Mozart to training; and, in a kindred art, that of Shakespeare to careful instruction.

In order to enable us to deal with the effect of cost in producing the labourer on the rate of wages earned by the labourer, it will be convenient to explain the other element in the definition or law given above. Wages must include the cost of maintenance. No one could reckon the profit earned by a machine, unless he first deducted the cost of supplying the machine with the force necessary for its motion. So with the wages of labour. Now this cost varies with the labour. Take, for example, a physician in practice, a clerk in a counting-house, and an artisan. The first of these will be put to considerable cost in providing his home and his equipage, and in his manner of life. The second will need to have his home and his dress of such a kind as will probably be a considerable charge on his earnings. The last may be clad in very cheap garments, and does not need, as far as his habitation is concerned, any but the commonest and cheapest kind of lodging.

We now come to the most important constituent in determining the cost of labour, or the rate of wages, phrases which we will temporarily take to be synonymous. I say temporarily, for it is clear that low wages may mean dear labour, and high wages may mean cheap labour. If we merely gave the cost of their keep as the wages of a troop of unskilled and listless savages, as the condition of their performing the manual labour of a farm, we should find that our bargain would be a bad one. Contrariwise, if we were able to pick out the best farm workmen and artisans we might, even though we gave them wages which were considerably in excess of the average rate, we should find that the increased charge would be more than counterbalanced by an increased gain.

For the purpose of argument, however, we must assume that the labour is average in point of effectiveness, and that therefore the wages paid correspond to the cost incurred in producing that on which the labourer is engaged. We have taken into consideration what the charge is which must be incurred by the labourer himself, in order that he may be able to work at all; in other words, we have accounted for the cost of his maintenance. Besides this, we have assumed that the supply of labour is not in excess of the demands of the public; or, to vary the phrase, we are considering that labour only, the quantity of which is ordinarily equal to the use which the general wants of society can find for the service which is tendered. The remainder of the workman's wages is exactly proportioned to the cost or difficulty which has been incurred in order to provide him at all. If this cost has been high, the wages paid will be high; if, on the contrary, it is low, the wages will be low. It makes no difference how the cost has been diminished, whether it be brought about by the fact that the workman has been brought up and trained at the public expense, or has been cheaply taught by his relatives and friends. Similarly it makes no difference whether the workman has been made scarce or costly because it is hard to train him, or because some artificial expedients have been adopted in order to make his service expensive. The illustration of these several means by which labour may be made cheap or expensive will form the subject of this paper, and will amply prove my contention.

Some workmen are brought up and trained at the public expense, both for the highest and for the commonest callings. Thus, out of a feeling of religion or humanity, the practice of modern society will not allow any destitute person to starve; and least of all, those who are destitute without any fault of their own—such as children who have lost their parents, or have parents who are unwilling or unable to support them. Such children are maintained and educated by public charity, the funds necessary for the process being compulsorily levied on the occupiers of property. Now these children, if they are brought up, as they must be brought up, to compete for employment against others, reduce the average wages of all against whom they compete, by the cost of their bringing up. Similarly, the principle operates in the case of those who are bred up to professions, or assisted in entering such professions, by the funds which are derived from educational endowments. Long ago, Adam Smith pointed out that the scanty incomes obtained by clergymen in his time were, in part at least, to be ascribed to the fact that in a great measure the cost of their maintenance and education was defrayed from the endowments of the two great English universities. Again, there

is hardly a country in the world where the remuneration of the teacher is, on the whole—particularly in those branches of learning which require long and careful preparation—lower than it is in England. The reason referred to already is the explanation of this fact. The endowments in aid of the work done by the teacher are very great in this country, amounting, in the aggregate to several millions of annual income, and devoted partly to preparing the teacher for his calling, partly to assisting him with an income after he has entered on his calling. It is probable that half the students in Oxford and Cambridge are assisted largely in the cost of their education, and everybody knows how numerous, and in some cases how wealthy, endowed grammar-schools are. These permanent contributions to the education and incomes of teachers lower the sums which are paid to those who do not share in them.

Again, if the skill needed for any calling is cheaply imparted, the labour, however skilful it may be, is always scantily remunerated. A good agricultural labourer knows more than any other workman does. His knowledge is the growth of ages of accumulated skill. It is astonishing to think how many difficult operations he is competent to perform. None but they who have tried it can conceive how difficult it is to drive a long straight furrow, of uniform depth, with a plough. It is really a high art, and needs long and careful teaching. But this is only one among many kinds of skill which a good farm hand possesses. Still he is the worst-paid labourer in the country, and it is a wonder how he can live. The rule, however, which has been given above will explain the reason. He costs very little to bring up. From his earliest years he is set to farm work, and so earns his poor living. As soon as he has strength to do so, he follows his father to the plough, and gets instructed in his calling. His eye and hand are continually being educated in the numerous operations which he will be called on to perform, and which he will perform well. If, on the other hand, he was debarred from earning his living till he reached, or nearly reached, the maturity of his powers, his wages would be far higher than they are under his present circumstances.

I will now deal with such instances as exhibit the contrary phenomena. There are some callings in which the opportunity for earning a living is only accorded after a protracted delay. Such a calling, for example, is that of a barrister. The mere education of a barrister is not very expensive. At any rate, it is far less costly than that of many other callings. But the chance of success is doubtful; and, except in very rare cases, the fact of success is very slowly realised. Many men do not obtain a moderate income in this profession till they have reached middle life. As a consequence their training is peculiarly costly, for, in accordance with the rule given above, the successful advocate is remunerated not only for his own outlay, but for the outlay of those who are unsuccessful. The same facts are found in those occupations where great personal reputation is needed in order to command remuneration. Such a reputation is naturally of slow growth, and is accorded only after great scrutiny on the part of those who repose trust in the individual. It is no easy matter for a man to acquire fame as a physician, or as an attorney.

The same circumstances surround those callings in which the cost of producing the labourer are artificially enhanced, and the same consequences ensue. It was with a design to obtain larger wages for equal amounts of skill and labour that the custom of requiring an apprenticeship was first established, and has since been maintained. It is to prevent the flooding of a calling with a host of competing labourers, and thereby the lowering of wages in that calling, that combinations of artisans have carefully regulated the conditions under which persons can be admitted into this or that kind of so-called skilled labour. No business is easier to learn than that of a bricklayer. It is not supposed that there is any great labour required in order to fit a man to become a compositor. Were these callings thrown open to any one who might choose to qualify himself in any irregular manner, there is little doubt that many could do so, and that by these means the rate of wages in these and many analogous callings would be greatly lowered.

Wages, then, may be lowered either because the workman is assisted in obtaining the skill necessary for carrying on his calling, or because he learns the business in which he is engaged with little cost, and at an early period. On the other hand, they may be heightened because the period at which the workman earns his living is usually late in his life, and because his training is therefore costly; or the workman may, by some expedient, be debarred from learning his craft easily, or taking to it in early youth. In all these cases the rule laid down above is illustrated—that the rate of wages conforms to the cost of producing the labourer.

SEATS OF INDUSTRY.—XXXII.

LEITH.

BY WILLIAM WATT WEBSTER.

LEITH is the principal port on the eastern coast of Scotland, and until quite recently it was the sole harbour of Edinburgh, the capital of the northern division of the kingdom, of which it may be said to be a commercial and manufacturing suburb. The greater part of Leith is built on the level ground on both sides of a small river called the Water of Leith, near its confluence with the Frith of Forth, and is about two miles distant from Edinburgh, but an unbroken line of houses now connects Leith with the Scottish metropolis. This proximity to Edinburgh has powerfully influenced the fortunes of Leith. It is a striking instance of a port that has had, and still has, to contend against natural disadvantages of a formidable description; but which, nevertheless, has contrived to maintain, to a great extent, the commercial pre-eminence it early acquired among the sea-coast towns of Scotland.

In the twelfth century Leith was already a town of some note. The earliest reference to it that has been discovered occurs in the charter of Holyrood Abbey, which was founded by David I. in 1128. It is there termed *Inverleith*, and, so far as is known, this is the original name of the town. In 1313 the shipping in the port of Leith was burned by the English, and in 1329 the magistrates of Edinburgh obtained a charter from King Robert Bruce, granting them the harbour and mills of Leith. Subsequently the authorities of the capital purchased all the other rights and privileges of the town from Logan of Restalrig, and its municipal government and harbour administration remained in their hands until the passing of the Scottish Burgh Reform Act in 1833, which conferred on Leith the right of electing its own magistrates and councillors, and of managing its own municipal affairs. It was visited again by an English fleet in 1410, and its shipping destroyed. Before the close of the fifteenth century, we find the magistrates of Edinburgh abusing the extraordinary powers placed in their hands by Robert I., for in 1485 they passed an Act ordaining that no merchant of Edinburgh should presume to enter into partnership with an inhabitant of Leith under the penalty of forty shillings Scots, and the loss of the freedom of the city. The subjection of Leith to Edinburgh naturally excited bad feeling between the inhabitants of the two towns, and the jealousy survived for some time after Leith acquired its independence. A bridge was built over the river in 1493 by Robert Bellenden, Abbot of Holyrood House, which was used till 1788, when the first drawbridge was erected. In 1544 Leith was almost entirely destroyed, and its whole shipping was carried off by an English fleet under the command of the Earl of Hertford; and five years later a body of French troops sent to assist Mary of Guise, the Queen Regent, in the attempt she made to suppress the Reformation in Scotland, took possession of the town. Leith was besieged and captured in 1560, by the combined forces of Queen Elizabeth and the Lords of the Congregation, the leaders of the Scottish Protestants. The Solemn League and Covenant was subscribed by many of the inhabitants in 1643; and in 1649 the town suffered from a plague, which proved fatal to 2,000 out of the 4,000 inhabitants it then contained. After the defeat of the Scottish army by Cromwell at Dunbar, in 1650, Leith was occupied by an English force, under the command of Major-General Lambert, while the Protector took possession of Edinburgh; and shortly afterwards General Monk took charge of Leith. This last-mentioned officer induced several English families to settle in the town, and to their influence a large portion of the commercial enterprise subsequently manifested by its inhabitants is ascribed. During Cromwell's occupation of Leith, the inhabitants petitioned him to relieve them from "the sad and most grievous oppressions" they lay under from the magistrates of Edinburgh, but without effect. Cromwell repaired the fortifications of the town, and erected a citadel with five bastions at North

Leith, for the purpose of defending the harbour. A large portion of these works were demolished at the Restoration. Races were introduced at Leith in the reign of Charles II. The citadel was held for a short time by the Pretender in 1715. In 1779 the American privateer officer, Paul Jones, appeared in the Forth with three armed ships, and created a great panic by threatening to destroy all the vessels in the Frith and harbour; and about 1783 a battery of nine guns was erected to the west of the site of the citadel, for the protection of the port. This battery was afterwards enlarged into a fort and garrisoned by the Royal Artillery, Leith being the head-quarters in Scotland of that branch of the military service. At one period Leith was walled in on the land side.

Within the last one hundred and fifty years very large sums of money, partly supplied by the Government, have been spent on the improvement of the port. In 1720 a dock was formed on the east side of the river, and in 1777 a small quay, called the Custom-house Quay, was built. In the year 1800 a magnificent suite of wet-docks was planned, and by 1817 two were completed, each measuring 750 feet in length by 300 feet in width, and having a united area of about 10 acres. In 1831 an addition of 500 yards was made to the Old or East Pier, which, however, still gave but 17 feet of water over the bar at its mouth at high spring tides, so that no vessel above 400 tons could enter the harbour without lightening. Between 1848 and 1855, more gigantic works were constructed, including the formation of the Victoria Dock, which is equal in size to any of the others; the erection of the New or Western Pier and low-water landing slip; and the extension of the Eastern Pier 1,000 feet seawards. Vessels of 2,000 tons burden can be accommodated in the Victoria Dock. By the extension of the piers, which approach each other at their extremities, leaving an entrance of 250 feet, ships are enabled to get into smooth water in easterly gales sooner than formerly. The harbour stretches out upwards of a mile into the Firth of Forth, and has a depth of from 20 to 25 feet at high water. A line of railway has been laid on the Western Pier, so that vessels may use it either in discharging the whole of their cargoes, or in lightening in order that they may proceed up to the inner port. These piers are unsurpassed, and in addition to other useful purposes, they furnish the citizens with a healthful and pleasant promenade. Lighthouses are erected on both piers. The aggregate length of the quays is 8,400 feet, and they, together with the docks, are lined with extensive warehouses, furnished with powerful cranes and other machinery for loading and discharging, and have a line of railway connecting them with the Leith terminus of the Edinburgh, Perth, and Dundee line, and also with the North British Railway. There are six graving docks at Leith, one of which is 400 feet long by 80 feet broad at the coping, and 24 feet deep on the sill at spring tides. But, notwithstanding all that has been done, Leith is not by any means a thoroughly efficient port. Commenting on the enormous outlay that has been made on the harbour of Leith, and the results that have been obtained by it, Mr. J. R. M'Culloch says:—"The object in carrying out the piers was to form a harbour which at their extremity should have water sufficient to enable vessels to come to the landing stage at all times of the tide. But this object has not been fully attained; and though it had, we should have been inclined to regard the outlay upon it as little better than thrown away. The truth is, the docks and the new harbour at Leith are entirely misplaced. Instead of being where they are, the docks should have been constructed at Trinity or Granton, about three-fourths of a mile or one mile from Leith, being, however, nearer to it than the extremity of the new pier." A harbour has been formed at Granton by the Duke of Buccleuch, consisting of a pier built on the most approved principle, in the shape of the letter T, having harbours and landing stages on both sides, and projecting into the sea about 1,700 feet, and the duke has also constructed a breakwater. Previous to 1866, Granton was a creek of the port of Leith, but in that year it was made an independent port.

The manufactures of Leith are numerous and considerable, but it is to its commerce that the town chiefly owes its importance. In 1692 the shipping belonging to the port consisted of 29 ships, with an aggregate burden of 1,702 tons. In 1850 the shipping registered at Leith numbered 210 of which 187 were sailing vessels aggregating 19,490 tons burden, and 23 were steamers aggregating 3,790 tons; while in the same year 2,349 sailing vessels, representing 164,000 tons burden, and 807 steamers representing 191,060 tons entered the port, and 1,203 sailing vessels, with a total burden of 98,872 tons, and 800 steamers, with a total burden of 190,687 tons, cleared the port. In 1855 the number of vessels belonging to the port amounted to 168 sailing ships of an aggregate of 19,067 tons, besides 25 steamers of an aggregate of 6,326 tons. The total value of the exports in 1859 amounted to £872,673, and the Customs revenue of the port in the same year amounted to £572,872. In 1862, 4,761 vessels, with a total burden of 930,670 tons, entered and cleared the port. Among the principal imports of 1862 were 481,530 qrs. wheat, 213,538 qrs. barley; 47,075 qrs. oats; 51,547 qrs. beans and pease; 11,746 qrs. Indian corn; 86,192 sacks and barrels of flour; 58,352 loads of timber; 14,604 tons of guano; and wine and tobacco also figured largely in the returns. The registered shipping in 1864 consisted of 136 sailing vessels of a total burden of 23,614 tons, and 63 steamers of 13,984 tons burden. The Customs duties on goods imported into Leith in 1867 amounted to £607,264, and there belonged to the port in that year 84 sailing vessels of 50 tons and upwards, and 58 of less than 50 tons, the aggregate burden of the former being 22,479 tons, and of the latter 1,798 tons, and 52 large and 21 small steamers having a joint burden of 20,859 tons. The proportion of steam vessels to sailing ships, it will be observed, steadily and rapidly increases. Leith has an extensive foreign and colonial trade with Russia, Holland, Denmark, Sweden, Germany, the Levant, the East and West Indies, America, China, and Australia; but it is with the northern countries of Europe, and especially with the towns on the shores of the Baltic, that most business is done. It has frequent steam communications with St. Petersburg, Copenhagen, Rotterdam, Hamburg, Dantzig, etc. The home trade of Leith is also very large, and steamers ply constantly between it and London, Liverpool, Hull, Newcastle, Greenock, Glasgow, Aberdeen, Wick, Lerwick, and other British ports. The chief exports of the town are iron, hardware, machinery, coal, cottons, linen, silks, woollens, and haberdashery. Its principal manufactures consist of ropes, canvas, soap, candles, colours, paints, leather, bottles, and glass, the latter industry having been, it is believed, introduced into Leith by English settlers in the time of Cromwell. It also possesses several large ship-building yards, a sugar-refinery, meat-preserving and fish-curing establishments, several breweries, a distillery, extensive saw mills, cooperages, and iron foundries, and a number of very extensive flour mills.

Previous to the passing of the Reform Bill in 1832, Leith had no representative in Parliament, but since that time it has sent one member to the House of Commons. The local government is vested in a Provost, who bears the ancient title of "Admiral of Leith," four baillies, a treasurer, and councillors. The courts held by the magistrates are designated the Admiral and Bailie Courts. In 1851 the district of Leith, embracing Leith, Musselburgh, and Portobello, contained a population numbering 30,919, which in 1861 had increased to 45,417, and is still growing. On the whole, Leith has a mean and dirty appearance, and in the older quarters of the town the streets are narrow and inconvenient, and the houses closely built and dilapidated; but many of the more modern streets, especially in the neighbourhood of the "Links," an open down on the south-east, are wide thoroughfares, lined with handsome houses. The part of Leith which stands on the north-west side of the river is known as North Leith, and that on the opposite side as South Leith. It is in the former that the principal places of business, warehouses, and even residences of the merchants are situated. Among the public buildings the most noteworthy are the Town Hall and Court House, built in 1828, where the Borough and Sheriff Courts are held; the Custom House, a Grecian structure with pediment and columns; and the Trinity House, built in 1817, in place of the edifice erected in 1555, which is adorned with a large and important picture by David Scott. The Female Asylum for Incurables, which was given to the town by Sir John Gladstone, the Premier's father and a native of Leith, deserves mention. This noted Liverpool merchant also built a church called St. Thomas, in his native town, which he handed over to the General Assembly of the Established Kirk of Scotland. The Rev. John Home, the author of "Douglas," and the solitary dramatic writer of any note that Scotland has produced, and Hugh Arnot, the historian of Edinburgh, were natives of Leith.

TECHNICAL DRAWING.—LXXVII.

DRAWING FOR CABINET MAKERS (*continued*).

THE first subject of this lesson (Fig. 605) is a portion of a piece of furniture called a *Secretaire*, adapted either for a library, parlour, or bedroom. It consists of two heights; the upper one being fitted with shelves to contain a small selection of books, whilst the lower case contains drawers. The upper portion of this lower case is not, however, a drawer as appears externally, but is provided with a hinged flap, which folds down on its lower edge so as to form a writing-board; and behind this is the nest of pigeon-holes shown in the present example.

In this nest the pigeon-holes are ranged above the drawers, the space in the centre being closed by a small door, opened and shut by a secret contrivance; and behind this are other pigeon-holes and drawers for cash or private papers.

The door is hung on pivots placed horizontally at about $\frac{3}{8}$ inch from the top, and is so arranged that on being pressed inward at the top it yields backward and tilts out below, affording a hold by which it is raised parallel to the cross-cheeks, and thrust into them.

In commencing to copy this example, draw the perpendiculars *a* and *b*, and the horizontals *c e* and *d f*, thus constructing the rectangle *c d e f*, which is the boundary of the nest of pigeon-holes. Next draw the pilasters and cornice of the whole case, and the horizontal line *g h*. The rectangle *d f g h* is the edge of the writing-flap, which is here represented as turned down at right angles to the front of the secretaire, in order fully to expose the pigeon-holes. Draw the inner line of the nest, representing the thickness of the wood, and then the horizontal line *i j* dividing the pigeon-holes from the drawers. The rectangle *c e f d* is now divided horizontally into two others. In the lower portion set off on each side the upright cheeks of the middle compartment *k l*, rule the horizontal lines, and divide the left and right spaces into drawers.

Now carefully divide the upper compartment into twelve equal parts, and on each side of the points of division set off half the thickness of the wood forming the sides of the pigeon-holes; across these draw the springing-line for the arches, and on this set off the centres from which these are to be struck. The rest of the subject will now be easily followed from the example.

The next subject (Fig. 606) is the front elevation of a dwarf mahogany book-case, drawn to the scale of 1 inch to the foot.*

In commencing to copy this object, having drawn the ground-line and the external perpendiculars for the sides of the case, draw the two horizontal lines representing the thickness of the top. Next draw the bottom line, and then the inner edges of the pilasters. This may be followed by the narrow fillet, which is the bottom of the transverse member, representing an architrave supporting the top, but in reality forming a portion of the main framing of the case, as will be seen by the section, Fig. 607.

The shelves are now to be drawn; but on this head no instructions will be required. The feet are to be commenced by a central perpendicular, crossed by a horizontal dividing the two portions. On this line are situated the centres from which, with radius extending to A, the upper curves are struck; the centres for the lower curves are on the ground-line, at the distance marked B.

Fig. 607 is the section on A B. From this it will be seen that the top does not depend only on the general carcase of the case, for, as is seen in the elevation, the whole front is open, whilst the section shows that the back affords but little support, since it consists merely of a framed panel, screwed into the sides, the cross-pieces, and the bottom. The main support of the top is obtained from two stout pieces of timber, the section of which is shown at *c* and *d*. These are at their ends dovetailed into the tops of the sides; the one is screwed to the front ledge, whilst the framing of the back is screwed (as already described) to the other. The object of this additional strength in the top of the case is to provide for heavy objects, such as air-pumps, microscopes, and other philosophical instruments, being placed upon it.

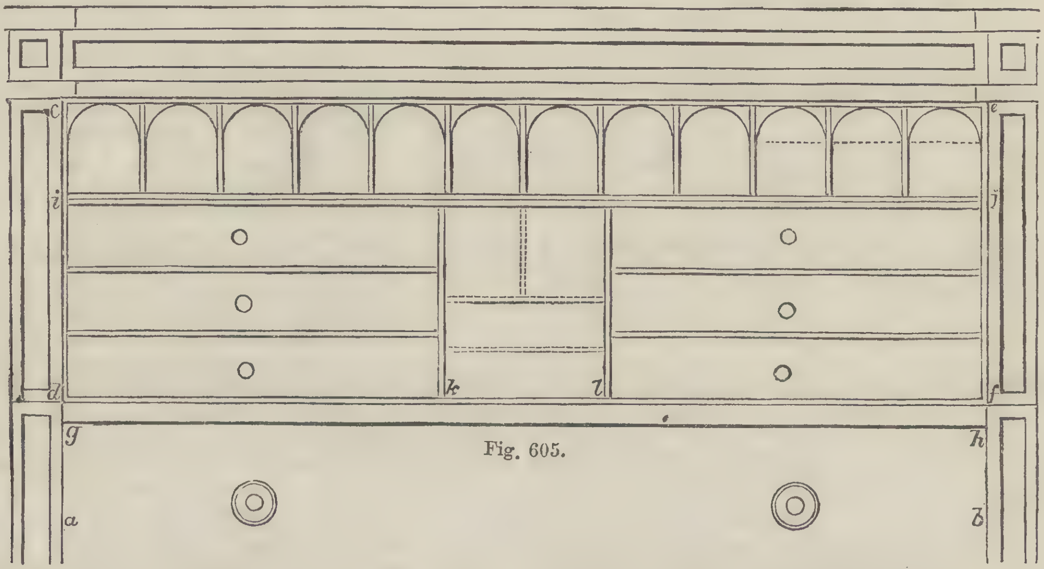


Fig. 605.

The inside of the book-case is provided with movable shelves resting on racks. These consist of a pair of toothed slips, *e f*, (about) $1\frac{1}{4}$ inch broad by $\frac{3}{8}$ inch thick, exactly similar to, and equidistant from, each other, glued along the insides of the walls of the case. Cross-ledges, *g g*, of the same thickness, and bearing the shelves, *h h*, are fitted between the slips, so as to rest on the teeth of the slips, with which, when pressed in, they become flush, and the heights of the shelves may be changed as required by moving the cross-ledges.

In simple book-shelves this is sometimes accomplished by cutting saw-like grooves in the sides, and bevelling the ends of the shelves, which thus slide in and out. This could not be applied in the present case, since the front of the pilasters projects beyond the mere thickness of the sides; they are therefore put in obliquely, and then dropped down on to the ledges, a small piece being taken out of each corner to allow space for the slips.

Another method is by wooden pins placed in holes, ranged in pairs at different heights in the sides. This is not generally satisfactory, since the pins have a tendency to fall out, causing the trouble of removing the books in order to replace them.

The method of drawing the section is precisely similar to that

* For the method of constructing a plain scale the student is referred to the TECHNICAL EDUCATOR, Vol. I., page 38.

pursued in regard to the elevation, and therefore it is not deemed necessary to give any further directions. It will be observed that the top projects more at the back than in the front. This is to allow for the skirting near the floor, so that the top may be brought close up to the wall.

Fig. 608 is the front elevation of a small mahogany writing-table with drawers and desk-top. Fig. 609 is the end elevation, showing the method by which the top is raised or lowered. The upper surface of the body of the table, and the under surface of the top, are each sunk about $\frac{3}{8}$ inch to allow of the support lying flat between them when the top is flat. This support works on toothed slips or racks, so that the slant of the top may be adjusted as necessary, at will.

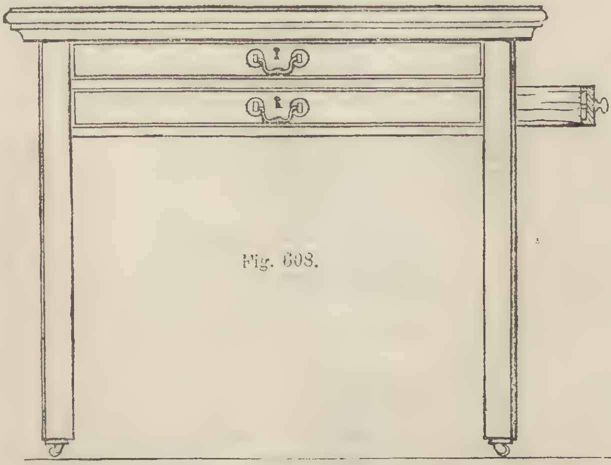


Fig. 608.

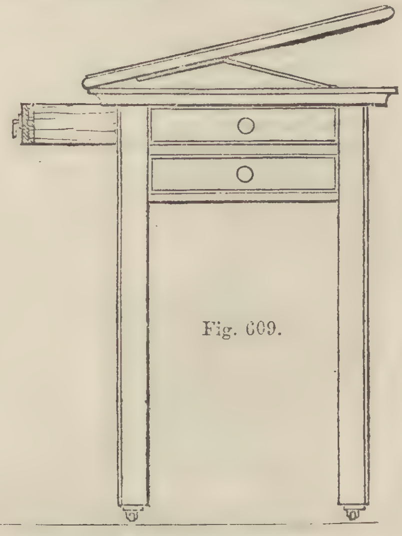
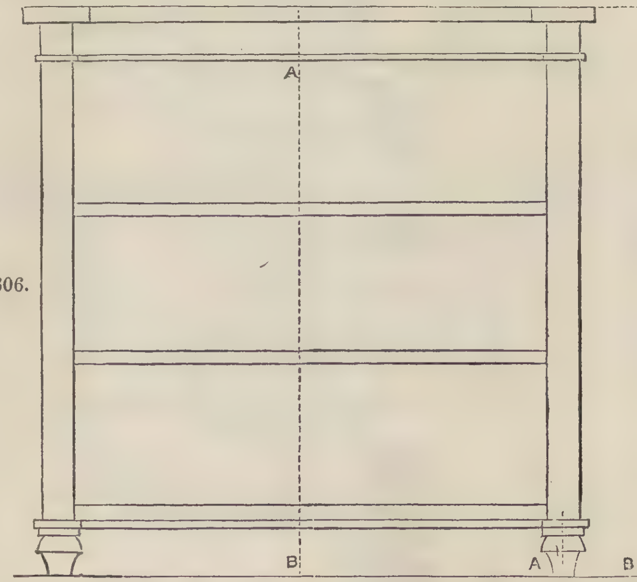


Fig. 609.

the perpendiculars for the legs; and it may here be mentioned that it will save time and add to the accuracy if both the views be proceeded with simultaneously, as the heights can thus be ruled with the same horizontal lines.

At a little distance, therefore, from the front, draw the perpendiculars for the legs of the end elevation. Having done this, next draw the horizontals for the framing, the top, and drawers, and unite those of the top by curves for the mouldings. Of course, in the end elevation the top is not formed by horizontal lines, and in copying the example the angle should be measured by the method shown in "Linear Drawing," so that the inclination in the copy may correspond with that of the original. The handles, castors, etc., do not call for any special instructions. The handles in the drawer and false drawer in the front of the writing-table are made of brass, and turn on pins passing through sockets in the circular plates, from each of which a screw projects, which is passed through the woodwork of the drawer, and fastened within by a nut. Handles of this kind are useful, as they admit of an easy application of the key. When solid knobs are used instead of a swing-handle, as in the side drawer which has no hole, and which therefore requires only one knob, two should be used, one on either side of the lock in the centre.

Fig. 606.



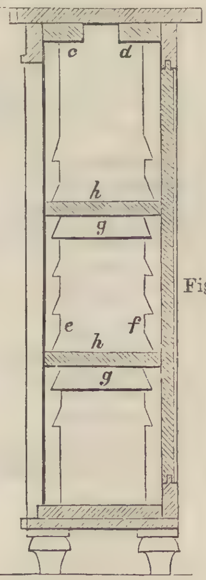


Fig. 607.

The top drawer in the front, and the lower drawer in each end, are made to open, the others being necessarily sham drawers; for it will be clear that the space which would be required for a bottom drawer in the front is occupied by the drawers in the end, and the space which would be wanted for the top drawers in the ends is taken up by the top drawer in the front. This is plainly visible in the two figures.

The outer edges of the legs are rounded off and beaded. In commencing these subjects draw the ground-line, and another above it, at a height equal to that of the castors. Next draw

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIX.

BY E. WYNDHAM TARN, M.A.

BILL OF QUANTITIES (*continued*).

JOINER AND IRONMONGER.

		Numbers in deal—
		63 housings of flyers to string . . . .
		6 ditto winders, ditto . . . . .
		15 ditto balusters to handrail . . . .
		4 ditto steps into newell . . . .
		30 ditto dovetailed for balusters . . . .
		6 rounded corners to shelf . . . .
		2 ditto 2 in. dresser . . . . .
		2 Ogee cut ends to stiles of sash . . .
		2 tongued angles to string . . . .
		10 ditto mitred angles to 15 in. skirting. .
		8 ditto mitres to 9 in. ditto . . . .
		3 dovetail blockings . . . . .
		2 pendants to newell . . . . .
		15 $1\frac{1}{4}$-in. square balusters . . . .
		30 $1\frac{1}{2}$-in. turned ditto . . . . .
		15 returned moulded nosings to treads . .
		15 cut brackets to string of stairs . . .
		1 curtail scroll end to step . . . .
		2 elbow caps. 2 soffits to boxings . .
FT.		Mahogany French polished—
2	2	Supl., $\frac{3}{4}$-in. wrought both sides . . .
11	5	„ 1 in. ditto seat and riser . . .
6	2	„ ditto beaded flap and frame . . .
34	6	„ ditto moulded and square framing
25	6	„ $1\frac{1}{4}$ in. ditto counter top, glued and blocked . . . . . .
24	6	„ 2 in. ditto astragal and hollow folding sash door, diminished stiles, lower panels moulded and bead flush . .
66	6	„ $2\frac{1}{4}$ in. lamb's-tongue shop sash . .
17	6	„ ditto, ditto, circular . . . .
3	6	Run, moulded nosing . . . . .
7	0	„ $\frac{1}{2}$ in. skirting, 4 in. wide . . .
15	0	„ 3 in. moulded handrail. . . .
3	0	„ ditto, writhe . . . . .
18	0	„ beaded door frame, 3″ × 3″ . . .
3	0	„ wrought and chamfered fillet . .
6	0	„ mortise clamp . . . . .
6	0	„ heading joint . . . . .
		Numbers in mahogany—
		1 dished hole in seat of water-closet . .
		1 beaded hand-hole, ditto . . . .
		2 rounded corners to skirting . . .
		1 fitting and hanging flap to counter . .
		4 mitres . . . .
		1 $\frac{3}{4}$-in. quadrant shelf, 9″ × 9″, on fillets .
		1 handrail scroll . . . . . .
		30 housings in handrail. . . . .
		Ironmongery and fixing—
		3 pair $1\frac{1}{2}$-in. wrought iron butts and back-flap hinges . . . .
		2 „ 2-in. ditto. . . . . .
		3 „ $2\frac{1}{2}$-in. ditto . . . . .
		1 „ 3-in. ditto . . . . .
		1 „ $3\frac{1}{2}$-in. ditto . . . . .
		1 „ $1\frac{1}{2}$-in. brass butts and gilt head screws
		3 „ 2-in. ditto . . . . .
		1 „ 4-in. ditto . . . . .
		1 „ 5-in. ditto. . . . . .
		2 cupboard locks. . . . . .
		1 iron-rimmed lock, and brass furniture .
		2 6-in. mortice locks, and china ditto . .
		1 10-in. drawback lock. . . . .
		1 patent latch . . . . . .
		2 brass escutcheons . . . . .
		3 brass sash fastenings . . . .
		2 ditto casement ditto . . . .
		1 wrought-iron shutter-bar, 3 feet long, and plates . . . . . .
		1 brass rack chain fastening . . .
		3 „ knob turnbuckle . . . .
		1 „ thumbscrew and plates . . .
		2 „ hook and eye . . . . .
		2 „ 10-in. barrel bolt . . . .
		3 handrail screws . . . . .
		2 screw bolts to newell . . . .
		1 screw nut and joint to newell cap . .
		1 cast-iron newell . . . . .
		2 ditto shelf brackets . . . . .
		6 japanned cloak pins . . . . . .
		2 pair china finger plates . . . . .
		4 ebony drawer knobs . . . . . .
		3 brass sunk flush rings . . . . .
		3 dozen brass hooks . . . . . .
		2 pair swing centres . . . . . .
		4 brass handles . . . .
		Carried to summary . . £

PLASTERER.

YDS.	FT.	
		Portland cement, with three parts sand—
53	6	Supl., render plain work on brick and jointed
27	4	„ ditto pilasters . . . . . .
37	11	„ ditto moulding . . . . . .
205	6	„ ditto hearths and floors . . .
38	3	„ dubbing out for extra thickness . .
FT.	IN.	
44	0	Run, arris edge . . . .
66	0	„ $4\frac{1}{2}$-in. reveals . . . . . .
70	0	„ 3-in. moulding . . . . . .
25	6	„ chamfered edge . . . . . .
52	0	„ 7-in. skirting . . . . . .
		Numbers in Portland cement—
		4 mitres to 15-in. moulding . . . .
		8 ditto 3-in. ditto . . . . . .
		10 brackets, 12″ × 6″ . . . . . .
YDS.		
44	0	Supl., render and rough cast . . . .
SQRS.		
$3\frac{3}{4}$		„ pugging $1\frac{1}{2}$-in. thick . . . .
YDS.	FT.	Parian cement—
57	0	Supl., trowelled for painting . . . .
0	21	„ pilasters . . . .
0	6	„ moulding . . . .
0	42	Run, quirk . . . .
0	45	„ skirting, 9-in. high with 3-in. moulding.
		Number—
		6 mitres to ditto . . . . . .
		Plaster—
57	0	Supl., render and set . . . . . .
57	0	„ ditto float and set . . . . .
$27\frac{3}{4}$	0	„ lath, plaster, and set . . . . .
$49\frac{3}{4}$	0	„ ditto float and set . . . . .
$77\frac{1}{2}$	0	„ stop, claircolle, and whiten . . . .
0	81	„ ditto, and distemper, two tints to cornice
0	162	„ cornice . . . .
0	87	Run, quirk . . . .
0	54	„ enrichment 6 in. wide . . . . .
		Numbers—
		12 mitres to 18-in. cornice . . . .
		2 36-in. centre flowers . . . . .
		Carried to summary . . £

SMITH AND BELL-HANGER.

CWT.	LB.	
		Cast iron—
36	109	Columns and girders . . . . . .
FT.		
3	9	Supl., casement and frame . . . . .
YDS.		
$8\frac{1}{2}$		Run of Ogee gutter, with clips and brackets .
$9\frac{1}{2}$		„ half round eaves, ditto . . . . .
16		„ 3-in. rain-water pipe, jointed with red lead
FT.	IN.	
10	6	„ balcony, 21 in. high, with wrought-iron top-rail and standards . . .
25	0	„ coping on 9-in. wall . . . . .
		Numbers—
		2 heads and shoes to 3-in. rain-water pipe .
		2 nozzles. 2 angles to Ogee gutter . .
		2 coal plates and hooks. 4 air-bricks . .
LB.		Wrought iron—
144		Chimney bars . . . .
217		Guard bars . . . .
$137\frac{1}{2}$		Shelf . . . .
$93\frac{3}{4}$		Rail . . . .
433		Bars . . . .
15		Lead for running . . . .
FT.		
15	0	Supl., $\frac{1}{2}$-in. wrought-iron door and frame, with hinges, lock, and brass knob . .
10	0	„ $\frac{1}{8}$-in. sheet-iron linings to panels, and drilling holes therein . . . .
		Numbers—
		40 points to 1-in. bars . . . . . .

	40 holes in ½-in. rail
	1 frame and door to copper
	30 ½-in. bolts, 15 in. long, with heads, nuts, and screws
	2 ditto, 12 in. long, ditto
	2 1-in. ditto, 12 feet long, ditto
	1 4 ft. 6 in. kitchener
	1 copper, weight 14 lb
	2 36-in. register stoves, steel front
	4 30-in. ditto, Berlin black

BELL-HANGER.

Number—	
	10 bells hung complete, with cranks, tubing, springs, back-carriage, pendulums, etc.
	4 ornamental lever pulls
	1 brass knob pull and plate
	1 ditto slide ditto
	Carried to summary . . £

PLUMBER.

CWT.	LB.	
45	0	Milled lead, and laying on roofs
2	1	Ditto, ditto, gutter
5	70	Ditto, ditto, hips
1	101	Ditto, ditto, step flashing
2	89	Ditto, ditto, cistern
17	6	Run, soldered angle to cistern
15	0	„ close nailing, with copper nails
12	0	„ ¾-in. strong pipe and joints
45	0	„ 1-in. ditto
35	0	„ 1¼-in. ditto
16	0	„ 1½-in. ditto
32	0	„ 5-in. soil ditto
		Numbers—
		2 solder joints to ¾-in. pipe
		2 ditto, 1-in. ditto
		2 ditto, 1¼-in. ditto
		2 ditto, 1½-in. ditto
		2 1¼-in. brass washer and waste
		1 1¼-in. trumpet standing waste-pipe, 27 in. long
		1 service-box soldered to cistern
		1 brass grating ditto
		1 ¾-in. ball-cock and copper ball
		1 ditto bib-cock
		1 1-in. stop-cock
		1 D-trap
		1 syphon-trap in 1½-in. pipe
		1 water-closet apparatus, with blue and white basin, brass handle, etc.
		1 2½-in. force-pump
		1 bend to 5-in. soil pipe
		Carried to summary . . £

ZINC-WORKER.

FT.		
120	0	Supl., 25 oz. zinc, laid on flats
24	0	Run, 4-in. eaves gutter and fixing
30	0	„ 2½-in. rain-water pipe, and ditto
		Numbers—
		2 octagon heads to rain-water pipe
		2 shoes ditto
		2 nozzles. 4 stopped ends to 4-in. gutter
		Carried to summary . . £

GAS-FITTER.

FT.	IN.	
55	0	Run, 1-in. wrought iron welded tubing
30	0	„ ½-in. tin ditto
		Numbers—
		5 short pieces of 1-in. iron tubing
		3 bends ditto
		2 tees ditto
		1 cross ditto
		1 connecting piece, ditto
		1 1-in. stop-cock
		8 ½-in. union joints
		4 12-in. plain brackets
		2 24-in. double ditto
		1 pendant with hydraulic joint
		1 5-light chandelier, ditto
		Carried to summary . . £

GLAZIER.

FT.	IN.	
62	3	Supl., glazing with seconds crown, in squares, 14″ × 10″
36	0	„ ditto, with best crown, in squares 18″ × 12″
19	6	„ ditto, with best 26 oz. British sheet, in squares 39″ × 18″
19	6	„ polishing to ditto
73	6	„ glazing, with ½-in. best British plate, in squares 7 ft. by 3 ft. 6 in.
10	0	„ ditto, with ¼-in. ditto, in squares 48″ × 15″
13	6	„ ditto, rough plate
24	6	„ bending plate glass
96	0	„ glazing in lead quarries with tinted cathedral, copper ties soldered on, and cementing to stonework
6	0	„ hacking out old glass
		Numbers—
		8 dozen squares cleaned
		4 glass tiles, 20″ × 10″
		Carried to summary . . £

PAINTER AND DECORATOR.

YDS.		
8⅓		Supl., knotting, stopping, priming, and 3 oils
31		„ ditto, 4 oils
4		„ ditto, to skylight, ditto
96		„ 4 oils, and flat ash green to plaster
10½		„ grained and twice varnished
FT.	IN.	
16	0	Run, knotting, priming, and 2 oils, shelf edge
34	0	„ ditto, 3 oils, cutting to treads of stairs
30	0	„ ditto, ditto, strings, ditto
240	0	„ ditto, 4 oils skirting
40	0	„ ditto, ditto, staff bead
96	0	„ grained and twice varnished, skirting
		Numbers—
		3 shutter bars, 3 oils
		4 sash frames, both sides, 6 ft. by 4 ft., 4 oils
		2 ditto, ditto, 8 ft. by 5 ft. 6 in. ditto
		8 doz. small squares, ditto
		2 ditto large ditto, ditto
		2 small casements, ditto
		4 stone chimney-pieces, 5 oils
YDS.		
4⅓		Supl., staining deal, sizing, and twice varnishing
40		„ distemper, two tints
IN.		
102		Run, 4-in. letters, gold and shaded
FT.	IN.	
48	0	„ 1-in. moulding gilt
		Carried to summary . . £

PAPER-HANGER.

YDS.	
47	Supl., canvas lining
36	Run, border
FT.	
130	„ 1-in. gold moulding, fixed with needle points
	Numbers—
	8 pieces of paper, value 1d. per yard, hung, including preparing and sizing walls
	11 ditto, 2d. ditto
	13 ditto, 6d. ditto
	15 ditto, marbled, 3d. per yard, hung in blocks, lined, sized, and varnished
	39 ditto, hanging lining paper, preparing and sizing walls
	Carried to summary . . £

SUMMARY.

Excavator and Well-sinker	
Bricklayer	
Tiler and Slater	
Mason	
Carpenter	
Joiner and Ironmonger	
Plasterer	
Smith and Bell-hanger	
Plumber	
Zinc-worker	
Gas-fitter	
Glazier	
Painter and Decorator	
Paper-hanger	
Total	£

SHIP-BUILDING.—XVIII.

BY W. H. WHITE,
Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DECKS OF SHIPS (*concluded*).

THE framing of decks occupies a position, in relation to what we have termed the "deck-flat," similar to that occupied by the frames of ordinary ships in relation to the skin planking or plating. Consequently the transverse beams do not aid the flat in resisting longitudinal bending strains, although they are most important aids to the maintenance of transverse form. There have, however, only been very few cases in which transverse deck framing has been given up in favour of other arrangements. Having to act independently, it becomes most important that the deck-flats should be made strong, in order that they may lend efficient help to the skin and the longitudinal pieces of the framing, in their resistance to longitudinal bending strains. This fact has long been recognised by writers on the theory of ship-building, but it has only within the last few years had any considerable influence on practice; and probably its general recognition at the present time is as much due to the necessity for much greater strength in the long ships now built as it is to any other cause. Wood ships were expected to display some amount of weakness in the upper works after having served for a moderate time, even when the best possible arrangements of the deck-flats had been made; and in the earlier iron ships the decks were little, if anything, stronger than those of wood ships, advantage not being taken of the superior qualities of the new material. This neglect led in some cases to serious, if not fatal, accidents. Such accidents, and evidences of weakness in numerous other cases, have so fully shown the necessity for giving a strong top flange to the ship considered as a girder, that builders now take steps to supply such a flange in iron ships; and we shall afterwards illustrate some of their plans. In many recent wood ships, too, a similar object has been aimed at, and to some extent attained; but before describing this modern practice it will be desirable to glance at the usual arrangement of the deck-flat in ordinary wood ships.

Wood ships with wood beams have their deck-flats formed by planking laid upon and fastened to the beams, as shown in Fig. 54, p. 36; hence the term "deck-flat" is commonly used instead of "deck-planking," although we have given it a wider meaning. In combining and fastening the strakes of deck-planking, care is taken similar to that described for the skin-planking. The strakes are almost always placed longitudinally, crossing the beams at right angles. Their butts are placed upon the beams, and shifted so that three passing strakes may come between consecutive butts on the same beam; the shift of butts is consequently identical with that for outside planking, shown in Fig. 27 (Vol. III., p. 256). The fastenings are also somewhat similarly arranged, only in the deck-planking they consist of nails or dumps (short bolts) driven into, not through the beams. With broad planks, double fastening is used in each beam; with narrower planks, double and single fastening is sometimes employed; single fastening is rarely used. Each of the butts is generally secured by two bolts driven into the beams.

We have already described how the deck-flat is bounded by the thin water-way, near the ship's side; and it will suffice to add here that towards the bow and stern, where the decks narrow rapidly, the strakes of plank lying nearest the side are ended successively. Nearer the middle of the deck, and stretching along by the sides of the principal hatchways, there are usually fitted several thicker and stronger strakes of planking, termed "binding strakes." These planks are carefully fastened to the beams (by scoring or dowelling), and running throughout the whole length of the ship, they form a valuable longitudinal tie. The remainder of the deck planking is usually of uniform thickness.

Where the hatchways occur special arrangements are required. The side-framing of these openings is formed, as said before, by longitudinal carlings let down between the beams, which form the foremost and aftermost boundaries of the hatchways. Upon these carlings "coamings" are fitted to enclose two sides of the hatchways, and upon the beams other pieces, named "headledges," of the same depth as the coamings, are secured to complete the enclosure. The inner binding strakes of the deck-flat fit against the sides of the coamings; and between the headledges of adjacent hatchways, the deck-plank has to be fitted in short lengths. In fact, this latter portion of the flat must be regarded chiefly as forming part of the deck, considered as a watertight platform; and it does not contribute much to the structural strength. It is impossible, however, to enter into detail further, and attention must next be directed to the arrangements of the deck-flat in a wood ship with iron beams, such as is illustrated by Fig. 55, p. 36.

The main portion of the flat in such cases consists of deck-planking worked directly upon the beams, and arranged with similar care to that of ordinary wood ships. In order to add to the strength of the deck, especially against hogging strains, the stringer-plate S is worked upon the beam-ends; and being carefully butt-strapped, as well as fastened to the beams and to the side, it forms a most valuable longitudinal tie. It, of course, helps the deck-planking somewhat also against sagging strains tending to compress the upper part of the ship; but this is of less importance than its assistance against hogging strains, because the butted planks at any cross section—amounting to no less than one-fourth of the total number of strakes—are effective against compressive strains, but almost useless against tensile strains. Experience with vessels constructed on this plan has proved that the addition of the stringer-plate is a very considerable improvement; and the fact is becoming generally recognised, although the use of such iron strengthenings is not yet common. From the sketch it will be obvious that these desirable results have been obtained without sacrificing simplicity of workmanship, or encroaching upon the internal space; in fact, as regards the first-named feature, the use of iron beams and stringers has made it possible to greatly simplify as well as improve the beam-end connections. The stringer-plates, it must be added, run throughout the whole length of the ship, and those on opposite sides of a deck are brought together and secured to each other at the bow and stern. By this simple arrangement the necessary connection is secured between the two sides of the ship, and all the elaborate devices of "ekings," "deck-hooks," "transoms," etc., required in a ship with wood beams are dispensed with. This is a matter of some importance, and it will not be out of place to illustrate it more fully. The ordinary practice in ships having beam-end connections similar to those shown in Fig. 54, p. 36, is to stop the shelf-pieces a little short of the bow and stern, the ends being rounded off just beyond the second or third beam from each extremity. For the remainder of the length a longitudinal timber named an "eking" is secured to the ship's side, the upper surface being well with the upper surface of the beams, and forming a support for the deck-planks. Close to the stem the eking is associated with a massive timber "breast-hook" or "deck-hook," which is bolted to and strongly connects the opposite sides; and right aft a corresponding timber known as a "transom" is fitted. In many cases the connection thus made is strengthened by large iron "crutches," forged so as to fit upon the inner surfaces of the deck-hooks and transoms, and bolted through them and the timbers of the frame. Contrasting this elaborate arrangement with the simple stringer arrangement possible with iron beams, it will be seen that the advantages attaching to the later plan are considerable.

The deck-planking in cases such as Fig. 55, p. 36, is secured to the beam-flanges by nut-and-screw bolts; but in wake of the stringer-plate the fastenings of the planks should be brought away from the beams, and placed in the intermediate spaces. By this means the beam-flanges are only weakened by the holes for the rivets securing the stringer-plate, and the deck-planks are enabled to aid the stringer against buckling under compressive strains. Sometimes the flanges of the beams are too narrow to receive the bolts securing the butts of the planks, and then it becomes necessary to rivet a small butt-plate to the beam under the butt.

Passing on to ordinary iron ships, we meet with an arrangement of deck-planking precisely similar to that just described, associated with some description of iron strengthenings. The most common forms of the latter are stringer-plates on the beam-ends, longitudinal tie-plates on each side of the principal hatchways, and diagonal tie-plates stretching from side to side between the hatchways. It is most desirable that the stringer-plates should be directly secured to the outside plating, with which they have to act in resisting bending strains, and to

accomplish this involves some trouble on some of the decks. For example, Fig. 56, p. 37, illustrates the kind of connection that would be employed on the main or lower deck of an iron ship. Notches have to be cut out of the stringer-plate in wake of the reversed frames, in order that it may be "fitted home" to the outside plating, and the connection of the two is made by means of short pieces of angle-iron. A continuous stringer angle-iron is fitted inside the reversed frames, in order to strengthen the connection with the side. This plan answers every purpose as long as it is not required to make the stringer watertight between the frames; but when the reverse is true, which is not commonly the case, other means are adopted. One of the simplest plans for securing watertightness is to fit short pieces of plate in the spaces between the frames, and to secure them by forged "staple" angle-irons, fitting accurately against the frames and plating; the stringer-plate proper running along inside the frames, and being secured to the short pieces of plates either by a lap-joint, or by a flush-joint with a covering edge strip.

The frames commonly end beneath the upper deck stringer-plate, so that it can be secured to the outside plating, or "sheer-strake," without difficulty, by a continuous angle-iron. Such a connection is obviously of greater importance on the upper deck than it is on either of the others, because failure is most likely to begin at the upper part if it occurs at all. In cases where exceptional strength is considered necessary, it is usual to obtain it by increasing the breadth and thickness of the stringer-plate, and by doubling the sheer-strake; and a similar course is often followed when ships display signs of weakness. Longitudinal and diagonal tie-plates are also fitted upon the upper decks of iron merchant ships to give greater strength—the former being intended to act with the stringer-plate in resisting bending strains, and the latter to lend some aid against such strains, in addition to preventing any "racking" in the deck. There is no doubt that these tie-plates are useful when so fitted; but it is questionable whether the material thus disposed might not be better placed in the form of an addition to the stringer-plate. This point has been much discussed by ship-builders, particularly as regards the use of the diagonal ties; and now Lloyd's Rules permit the disuse of diagonal ties, provided a certain additional strength is given to the stringers. The longitudinal ties at the sides of the hatchways are, however, still made compulsory by the Rules, although strong arguments may be advanced in favour of their disuse. Supposing, for example, that the iron used in these longitudinal ties were added to the stringer-plate, it would be intimately associated with, instead of being distant from, the skin-plating with which it is required to act; and, moreover, the stringer so formed would be likely to form in itself a more efficient longitudinal strengthening than is formed by the widely-separated stringer and tie-plate, which may or may not act jointly. On the other hand, it must be admitted that these longitudinal tie-plates form excellent strengthenings to the deck in wake of the principal hatchways, which are of considerable size; but the special strength required at these places can be obtained by other means of a simple character, in cases where no tie-plates are fitted. It may be interesting to add that in the unarmoured iron ships recently built for the navy tie-plates have been entirely dispensed with, and strong stringers alone fitted. One other matter of importance must be mentioned. In arranging stringer plates care should always be taken to make their butts give good shift to the butts of the strakes of skin-plating in wake of the stringers; and the butt fastenings of the stringer-plates and angle-irons should be made sufficiently strong.

Nearly all the preceding remarks apply with equal force to composite ships of the ordinary construction. In them there is an iron sheer-strake to which the stringer-plate is attached; and longitudinal and diagonal tie-plates are also employed. On all except the upper decks, however, it is usual to fit the stringer-plates within the reversed frames; and the reason is obvious, seeing that there is generally only a wood skin in wake of these decks. In some cases, however, strakes of plating are worked in wake of the beam-ends of all the decks, and then the stringer-plates are scored in between the frames and secured to the iron plating. No other points of difference in the deck arrangements of iron and composite ships demand notice.

Stringers and ties such as have been described give sufficient strength to the decks of most merchant ships, but in iron vessels of great size and length additional strength is needed, at least on the upper decks. This want has been met in many cases by adding considerably to the breadth of the stringer, and consequently forming what is termed a "partial iron deck;" and in other cases a "complete iron deck" has been formed by plating over the whole surface of the deck from the line of the hatchways to the ship's sides with continuous strakes, the middle-line spaces between the hatchways being either left unplated or else covered with thinner plating. Complete iron or steel upper decks have been long recommended by some of the greatest authorities on ship-construction; and they have been for many years employed in the iron-clad ships of the navy. Only recently, however, have they found much favour in the merchant service, although a few ships have been so constructed; but with the great increase in the lengths and proportions of ocean steamships, has come the conviction that nothing but advantage results from covering the upper deck with iron or steel plating, and the practice seems likely to become common.

A very brief description of the mode of fitting deck-plating will suffice. The plates are usually flush-jointed at both edges and butts, and consequently rest directly upon the beams, no liners being required. The edges are secured by continuous strips, single-riveted; the butts are covered by double or treble riveted straps. All the joints can be caulked, and the whole plating made watertight if required. In some cases the plan of lap-jointing is resorted to, and the plating arranged just on the same plan as the skin-plating, but this necessitates the use of liners under the alternate strakes which do not fit upon the beams. The butts of the plates are carefully shifted with regard to each other, and also with respect to the butts of the sheer-strake; in fact, the latter precaution is almost as necessary here as it is when only stringer-plates are fitted, if the best possible disposition of the material is aimed at, as it should be, by the ship-builder.

Wood planking, arranged in the same manner as on the decks of ordinary wood ships, is almost always fastened upon the iron deck-plating, and secured by nut-and-screw bolts, which should be kept clear of the beam-flanges, in order that they may be only weakened by the riveting of the plates. Formerly this was not done, but the fastenings of the deck-planks were placed in the beam-flanges just as they would have been if there had been no iron deck. By placing them between the beams, the planking is also secured with greater ease, and it prevents the plating from buckling down under compressive strains. Intimately connected as they are, and each possessed of considerable strength in itself, these two assemblages of plates and planks mutually aid each other in resisting longitudinal strains. The iron or steel deck is of the greater importance when hogging strains have to be resisted, but even against these the wood deck is of considerable service; while the wood deck is most valuable in itself resisting sagging strains, and enabling the plating to develope its strength without buckling. Proposals have been made to give up wood decks when iron or steel decks are fitted, and some ships have been so built. Hitherto, however, it is the general opinion of ship-builders that the use of wood decks is most desirable, mainly on account of the greater comfort gained thereby; and to this must be added the foregoing considerations relating to the joint action of the wood and iron.

This simple arrangement of deck-plating is found to meet every requirement in ordinary iron vessels, and will doubtless lead to the entire disuse of the various detached strengthening pieces—such as "box-stringers," and "vertical stringer-plates"—formerly common in long iron ships. Special requirements, however, have to be met by special arrangements. For instance, in the *Great Eastern*, where extraordinary strength was needed, the upper deck was formed by two iron skins with deep longitudinal girders between; constituting, in fact, a cellular structure in itself capable of resisting great tensile and compressive strains. Again, in the iron-clad ships of the navy it not unfrequently happens that the deck-plating is arranged rather with a view to its powers of resisting penetration by projectiles, than with regard to the strength of the ship considered as a girder. All these exceptional cases must, of course, be considered independently; but in all of them the ship-builder must take care, while giving prominence to the special features, not to overlook the requirement of structural strength, securing both to the utmost extent possible.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVI.—HENRY MAUDSLAY.

BY JAMES GRANT.

Henry Maudslay, who was the leading workman of Joseph Bramah, and the inventor of the slide rest and the leather collar for the hydraulic press, was born on the 22nd of August, 1771, in an old house opposite the gates of Woolwich Arsenal. Though his father, William Maudslay, was but the storekeeper of the dockyard, he was the lineal representative of an ancient Lancashire family, to whom belonged old Maudslay Hall, near Ormskirk. Through some unfortunate love-affair he enlisted in the Royal Artillery, and served in the West Indies, where he was several times engaged in action, and on the last occasion received a bullet in the throat. After being invalided, he was discharged at Woolwich, but obtained some humble employment in the Arsenal, and ere long had the office of storekeeper assigned him.

When his son Henry was twelve years old, he was employed as a "powder-monkey" in making and filling blank and ball cartridges, and in 1785 he obtained employment in the carpenters' shop of the arsenal, and there first became acquainted with the use of tools and with working in wood and iron. "From the first," we are told, "the latter seemed to have had the greatest charm for him. The blacksmiths' shop was close to the carpenters', and Henry seized every opportunity that offered of plying the hammer, the file, and the chisel, in preference to the saw and plane. Many a cuff did the foreman of carpenters give him for absenting himself from his proper shop and stealing off to the smithy. His propensity was indeed so strong, that at the end of a year it was thought better, as he was a handy and clever boy, to yield to his earnest desire to be placed in the smithy, and he was removed thither accordingly in his fifteenth year."

He rapidly became an expert artisan, and was particularly skilful in forging light iron work, but his favourite employment was to cut "trivets" out of the solid, work which only the most finished hands in the shop could do. These were made out of Spanish iron bolts, which, "though exceeding tough, forged like wax under the hammer." The old workmen, with whom he was a great favourite, were wont to crowd about him when forging these trivets, which he did so quickly and neatly as to excite their admiration. This manufacture of apparatus for supporting toast-plates before the fire was not exactly required at the arsenal, and was strictly forbidden by the superintending officer, so that Maudslay's secret work had to be concealed every time he entered the shop.

He was always fond of any unusual piece of forging, or of having difficulties to overcome, and turned out many beautiful pieces of workmanship in the form of ornaments; but his dexterity as a smith became eventually directed to machinery. His fame as a handy and expert mechanic became known even in London, and his father, the old artilleryman, who was very proud of him, was wont to point to the old military leather stock, which had partly saved his throat from the bullet, and which he carefully preserved, and say—

"But for that bit of leather, there would have been no Henry Maudslay."

He now quitted Woolwich Arsenal and obtained employment in Piccadilly, with Joseph Bramah, who speedily made him foreman in his manufactory, and who was greatly indebted to him for the contrivance of many of those tool-machines which enabled him to carry on the business of lock-making with such profit and advantage. Bramah was inspired by an indefatigable spirit of invention, and the great success of his lock, which he patented in 1784, stimulated him to fresh efforts. His first invention, with the view of creating a motive power, was his hydrostatic machine, founded on the doctrine of the equilibrium of pressure in fluids, as exhibited in the "hydrostatic paradox."

This machine has been used on many occasions in preference to other methods of applying extraordinary power, where such was required, such as when Stephenson hoisted the giant tubes of the Britannia Bridge into their bed, and Brunel launched the *Great Eastern* from her cradles—the weight raised by a single press in the first instance being 1,144 tons! The chief difficulty of Bramah in the construction of the hydraulic press arose from the tremendous pressure exercised by the pump, which forced the water between the solid piston and the sides of the cylinder in such quantities as to render the press, at first, useless for practical purposes, and he found himself completely baffled by this result.

"In this dilemma," says Mr. Smiles, "Bramah's ever-ready workman, Henry Maudslay, came to his rescue. The happy idea occurred to him of employing the pressure of the water itself to give the requisite water-tightness to the collar. It was a flash of common-sense genius—beautiful itself in its simplicity."

Maudslay's invention is thus described :—

"A collar of sound leather, the convex side upwards and concave downwards, was fitted into the recess turned out in the neck of the press-cylinder, at the place formerly used as a stuffing box. Immediately on the high-pressure water being turned on, it forced its way into the leathern concavity and flapped out the bent edges of the collar, and in so doing caused the leather to apply itself to the surface of the rising ram with a degree of closeness and tightness so as to seal up the closer, exactly in proportion to the pressure of the water, in its tendency to escape. On the other hand, the moment the pressure was left off, and the ram desired to return, the collar collapsed and the ram slid gently down, perfectly free and yet perfectly watertight. Thus the former tendency of the water to escape by the side of the piston was, by the most simple and elegant self-adjusting contrivance, made instrumental to the perfectly efficient action of the machine; and thus, from the moment of its invention, the hydraulic press took its place as one of the grandest agents for exercising power in a concentrated and tranquil form."

Maudslay's father died soon after he entered the employment of Bramah, and every Saturday night he walked down to Woolwich, to hand over to his mother the largest share of his week's wages. His fellow-workmen considered him as the hero of the shop, and as he was tall and handsome, on gala days, when the men turned out for a procession, they insisted that he should march at their head, immediately behind the band, and carry their flag. As manager of Bramah's extensive works, Maudslay quite won the heart of his master; but he did more, for he won the heart of the housemaid, a pretty girl named Sarah Tindal, whom he married, and who made him an admirable wife.

Maudslay was eminently successful in the ingenuity with which he devised tools for the most delicate and difficult parts of lock-making; and with his own hands he constructed that identical padlock which so puzzled and tested the powers of Mr. Hobbs in 1851. That lock had then been made for more than half a century, without any of the modern improvements, hence its power was doubly creditable to the skill and dexterity of the artisan who made it. With all the skill and activity displayed by Maudslay in the service of Bramah, his highest wages as manager of his works never exceeded thirty shillings per week. The expenses of an increasing family requiring more, his application for it was bluntly refused. Mortified by this unexpected result, he quitted Bramah and started in business on his own account, in a small workshop and smithy in an alley off Oxford Street. This was in 1792.

There his first customer was an artist, who ordered the ironwork for a large easel, embodying some new and complicated arrangements, and the work was done punctually and to satisfaction. Other orders followed fast. His fame as a skilled workman became as great as that of the master who had lost him, and many who used to do business with Bramah now followed Maudslay to the alley off Oxford Street. He was particularly careful in the style and finish of his work, and it was with this end that he aimed at the contrivance of so many improved machine-tools, which should be self-acting and self-regulating; and hence he invented that important mechanical instrument, with which his name is more usually identified—the slide rest. In this lathe the slide rest and frame were movable along the traversing bar, according to the length of the work, and could be placed in any position and secured by a handle and screw underneath. The rest, however, afterwards underwent many important alterations, but the principle of the whole machine was Maudslay's own invention.

One of the first uses to which he applied it, after he had commenced business in Margaret Street, Cavendish Square, was the execution of the requisite tools and machinery required by the future Sir Mark Isambard Brunel, for the manufacture of ships' blocks. He was then assisted only by a single journey-

man, but he speedily required many more, after the working models were ready for the inspection of Sir Samuel Bentham and the Lords of the Admiralty, in 1801. After being fully approved of by them, Mr. Brunel was authorised to proceed with the execution of the machinery requisite for the manufacture of the ship-blocks of the Royal Navy. The whole of this machinery was executed by Henry Maudslay. It occupied him nearly six years, so that the cutting of blocks by the new process was not begun until the close of 1808.

Many machines were requisite in the manufacture of a single block. Among these may be enumerated the straight-cross-cutting saw, the circular-cross-cutting saw, the reciprocating-ripping saw, and the circular-ripping saw, the boxing and mortising instruments—the latter for cutting stream holes, and furnished with numerous chisels, each making from 100 to 150 strokes per minute; and then came the corner saw, the shaping machine, and the scoring engine, for cutting grooves round the longest diameter of the block. With this new machinery ten men could perform the work which before had required a hundred and more to execute, and not less than 160,000 blocks of all sizes were turned out yearly, at a cost of not less than £541,000, the annual saving to the Government being estimated at £17,663.

This brought fresh accession of fame and business to Maudslay, who removed his works to the Westminster Road, Lambeth, 1810, and established there the famous co-partnery of Maudslay, Field, and Co. There he continued to improve his old tools and to invent new ones, until the original slide-lathes used for making the block machinery became antiquated, and thrown into the shade by the more gigantic machines of the present day. Among other work to which he turned his attention was the construction of plane and saw mills, mint machinery, and steam engines of all kinds; and the *Regent*, the first steamer that plied between London and Margate, was fitted with engines by Maudslay in 1816. He invented the machine for punching boiler-plates, and for many years held the contract for supplying the Navy with ships' tanks. As wealth and years came upon him, he never allowed himself to forget his skill in the use of the hammer, and to the last he took a pleasure in handling it, sometimes in the way of business, but more often through sheer love of his art and the memory of his early days. Among the last works executed by the firm during Maudslay's lifetime, was the famous shield employed by his friend Brunel in the excavation of the Thames Tunnel, the completion of which he did not live to see, as he died on the 14th of February, 1831.

By his own desire he was buried beside his parents in the parish churchyard of Woolwich, a district for which he ever had a great regard, and which he was fond of visiting from time to time. "He liked the clangour of the arsenal smithy," says the historian of industrial art, "and all the busy industry of the place. It was natural therefore that, being proud of his early connection with Woolwich, he should wish to lie there; and Woolwich on its part has equal reason to be proud of Henry Maudslay." A cast-iron tomb, designed by himself, is erected over his remains.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XII.—NATIONAL MUSEUMS (*continued*).

General Details, etc. (*continued*).—Another convenient arrangement, especially when delicate specimens have to be isolated for close examination in the studies, is that of the glazed boxes round and square, with corked bottoms. Usually, these are supplied "nested," consequently of various depths; but sets of subdivisions of a standard size, of a uniform height, afford the neatest arrangement for museum purposes. These may also be glazed on both sides, which like frames glazed on both sides are useful for the display of rare objects that require examination, both on their upper and lower surfaces. Flat bottles (Fig. 16), such as are employed by Mr. Twining, are useful for the display of seeds, powders, etc. Next in convenience are the ebonised bowls (Fig. 17), closed by glass discs that drop into a rebate in the rim. These are useful for the display of sands, grains of metals, small nuggets, etc. Where small quantities of material have to be made the most of, the bottoms of such bowls may be filled up with lenticular shaped blocks, A (Fig. 17), which bring the sand, etc., up to the covering glass. Allied to these are the specimen glasses (Fig. 18), covered with flat plates or watch glasses, that are specially suited for separate crystals, chemical products, etc. Cast rods of metals, etc., can be well displayed in tubes, the stoppers of which form stands as in Fig. 19. The hermetically sealed tubes in which the alkaline metals potassium, sodium, etc., are supplied are best mounted on an ebonised wooden foot that conceals the unsymmetrical portion, as shown in Fig. 20. Gems, crystals, etc., may be supported in shallow cups or on the points of ebony or ivory conical pegs, as in Fig. 21, or be held in the grasp of double or triple limbed tweezers (Fig. 22), with pointed ends that allow of such objects being placed at any angle that best catches the light to bring out its play or colour, etc. Preparation jars are round or oval, as shown in Fig. 23, are made of various sizes, but when filled with preservative fluids have the disadvantage of producing optical distortion, so that unless the object is very large, it is better to display dissections in flat cemented cells, built up of glass slips, slabs, and covers, or, better still, made from sections of square, oblong, oval, or round bottles, cemented to base and covering glasses, as shown in Fig. 24. Where objects are unsuitable for display in a public gallery, such as jelly fishes, microscopic objects, etc., they may be represented by transparent photographs which may be coloured with great delicacy, and a more perfect rendering of hyaline aspect than can be given in water-colour drawings. Such paintings on glass must be supported on tin frames of the form shown in Fig. 25, the upper half being japanned dead black, the lower half white; as this is for the purpose of reflecting light through the transparent illustrations, the tin allows of the glass being adjusted to the most suitable angle. In the elementary collections such photographs may be utilised as magic-lantern slides for the illustration of lectures to large audiences when colossal diagrams of objects described are essential to a clear comprehension of details of structure. This is the only way of showing lettered classifications, so as to be discernible in a large lecture theatre.* A very useful arrangement has of late years been introduced into museum fittings by Mr. Twining, shown in Fig. 26, that consists of an iron standard on a tripod foot, to which are hinged a series of iron frames that may be fitted with specimen bottles, trays, herbarium cards, diagrams or photographs, which may be turned over like the leaves of a book. These hold a great number of specimens, while they occupy little space, and would be of especial service in the botanical gallery. Strong iron cradles, frames, etc., made of iron, are required for the support of special objects, such as the tusks of the mastodon, carapace of the glyptodon, restored skeleton of the great extinct sloth, etc., at the British Museum.

Fig. 27 shows a convenient form of label. In tropical countries it is necessary to protect specimens from moth, white ants, and other destructive pests, by preserving them in tight-fitting metal cases, which, if required for public exhibition, may be glazed on the top side; attention being given to the way in which the glass is cemented into its fitting.

Details of Rotunda of Elementary Natural History.—As a small collection is found to be more readily understood and made available for the uneducated classes, and those who have not studied very profoundly—numerous specimens of species rather confounding than assisting such persons—the arrangement of this supplemental building is specially disposed for the display of an epitome of natural history or index collection, introductory to the systematic series, and for the same being open for inspection in the evening as well as during the day or even, as recommended by Dr. J. E. Gray before the Parliamentary Committee on the British Museum, on Sundays also. The elementary collections in this department should illustrate by external form, skeleton, skulls, dental formulæ, internal and microscopic structure, developmental phases and embryology, the characteristics of the classes and orders of the animal and vegetable kingdoms, zoological, botanical, and mineralogical terminology; and the classification being illustrated by the collections of British natural history, interspersed with the most important exotic species which have not representatives in the British series. All such specimens should be arranged so that they could

* See Vol. II., page 244.

be utilised for popular lectures on the general principles of natural history. As the typical collection would embrace a similar series to that which should form the basis of every local museum, I shall defer a detailed description thereof till I have to treat of museums of the latter class. The ethnological and geographical distribution collection should form one series, and be arranged in large groups, artistically arranged with scenic backgrounds in cases at least 10 feet deep, so as to convey a just idea of the natural association of plants and animals with the human race in geographical regions, and of the representative species of different countries, and distribution of life in oceanic

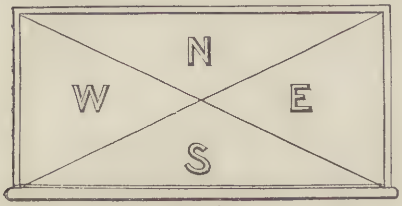


Fig. 28.

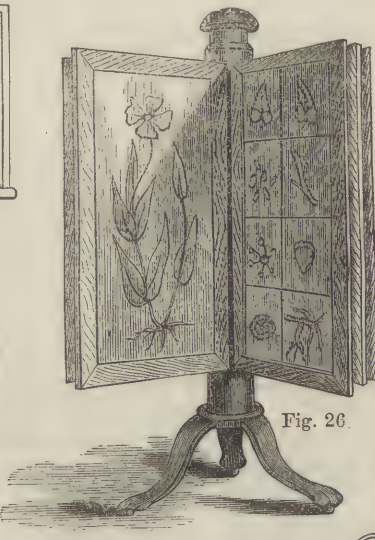


Fig. 26.

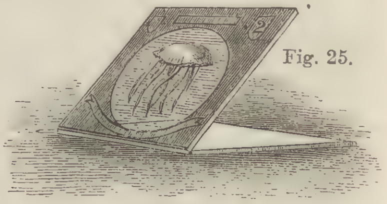


Fig. 25.

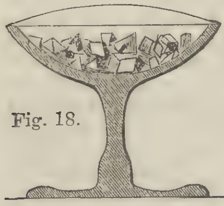


Fig. 18.

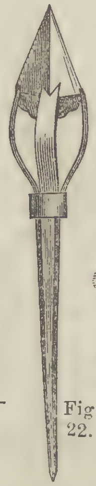


Fig. 22.

Fig. 16.

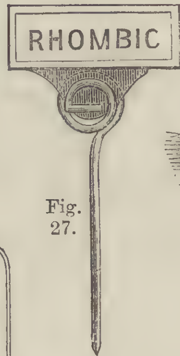


Fig. 27.

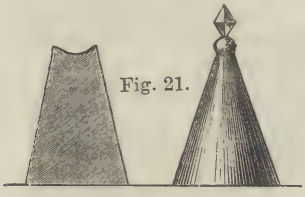


Fig. 21.

Fig. 17.

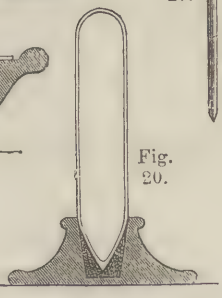


Fig. 20.

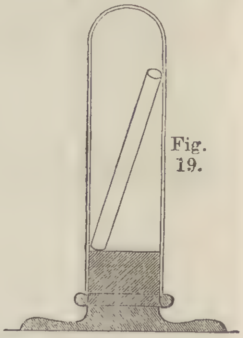


Fig. 19.

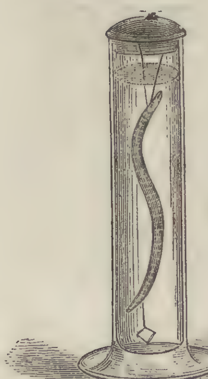


Fig. 23.

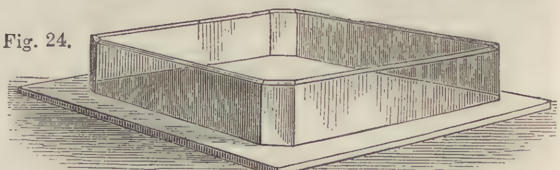


Fig. 24.

depths after the manner foreshadowed by the lamented Edward Forbes at the Crystal Palace, though such illustrations can only be regarded as sketches of what ought to be worked out in detail at the new Museum. Each case might be conventionall divided *in idea*, as indicated in Fig. 28, so that the species of every associated geographical group should find its place according as its maximum of development was to the north, east, south, or west of the geographical region illustrated. In the same room, the position of our earth in the solar system should be shown by a simple orrery, which should also indicate the relative diameters of the planets, their mean distances from the sun, and such other details as the huge dome of the Rotunda would admit of.

The floor of the ethnological and geographical gallery might be occupied with cases containing small models, such as those shown at the Exhibition of 1862 by Montanari and Heiser to illustrate varieties of the principal types of the human race, and the costumes of the inhabitants of the various regions of the globe. The life-like illustrations of bathymetrical distributions might be displayed in tall but shallow cases, artistically arranged to give an idea of sub-aqueous life, vegetable and animal.

Such a gallery would be one of the most popular as well as the most instructive in the elementary series, as being most readily comprehensible by the uneducated.

Details of Lecture Theatre.—This would be seventy feet in diameter, lighted by day from a glass ceiling opening into the dome of the Rotunda, after the manner of the theatre at the Museum of Practical Geology, and by night by a "sun-burner," which would also be an active element of ventilation. The thick glass ceiling could be guarded in the upper floor by a circular range of cases, serving the place of a balustrade without material loss of space. The theatre should be arranged to accommodate at least 1,000 persons, and provision should be made for the illustration of the lectures by monster diagrams, tables of classifications produced by aid of the demonstrating lantern, which is the only method of making structural details and lettered diagrams distinctly visible to the whole of a large audience, a method that year by year is gaining favour, and rendering the old magic lantern in its modernised form a powerful instrument of education, by the way in which it conveys information through the eye; and as long as we can teach well and quickly, "sight knowledge" is a thing not to be sneered at.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By Professor T. C. Archer.

I.—THE NATURE AND PROPERTIES OF WOOL.

The term *wool* is applied to that particular kind of hair which reveals, by aid of the microscope, a peculiar transversely imbricated structure, upon which chiefly depends its value as a textile material. Besides this peculiarity, wool possesses another which increases its usefulness: it is longitudinally waved.

These properties cannot be well understood without the aid of drawings, and these must be somewhat exaggerated in their details, as well as in their size. They exist in the greatest perfection in the fleeces of the cot-fed Merino sheep of Bohemia and Hungary, a tuft or lock of which is represented of rather more than its full length in Fig. 1. If from this we draw out a single hair, we shall find it is extremely thin, finer even than the thread of the gossamer spider, and that it is regularly waved in the manner shown in Fig. 2.

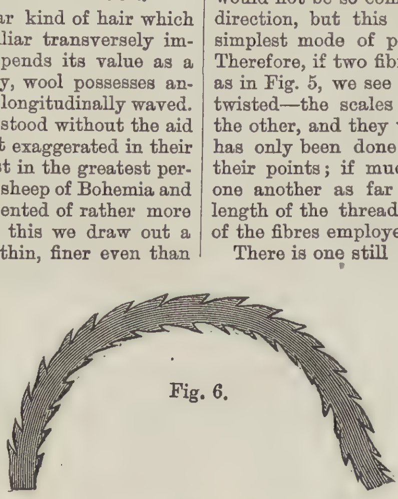


Fig. 6.

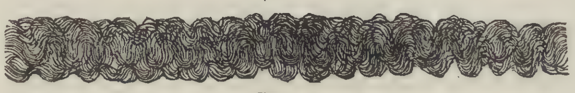


Fig. 1.

Fig. 2.

Fig. 3.

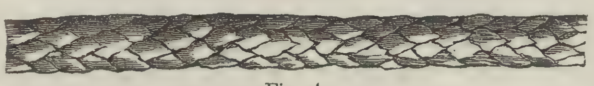


Fig. 4.

Fig. 5.

As we have before stated, this represents the highest perfection of one class of wools, which from their shortness are called *short-stapled;* but there are some other kinds in which this type is very widely departed from, in which the wool is very much longer, and the curves are altogether different, as in Fig. 3, which may be taken to represent the class called *long-stapled.* Between the extremes shown in these figures there is every possible gradation, and these qualities are more or less visible to the eye and touch of the experienced *wool-stapler*, and also to that of the manufacturer; but the other and more remarkable quality of wool, its imbricated structure, cannot be seen by the unassisted eye. As with the waves or curves, so also with the imbrications or scales, differences exist, which are distinctive of the short and long-stapled varieties. If we magnify a single hair of the finest *short-stapled* kind to about 150 diameters, we shall find that it is marked transversely by very distinct and apparently irregular striations, which will be seen on further examination to be the edges of scales overlapping each other, after the manner of tiles on a roof. Fig. 4 gives an exaggerated view of a fibre so magnified, and Fig. 5 an imaginary longitudinal section of two fibres laid in opposite directions. That the scales are free except at their bases, can be easily seen by examining one when bent, as in Fig. 6, when the scales will be lifted up at their points. These may appear very trifling matters, but they are of so much importance that without them wool could not be applied to the purposes of weaving by any of the processes now known. Besides the special form and arrangement of these scales, their number is also a matter of great importance, and this varies quite as much, or even more so, than the length of the curves; thus, in the very finest of the *short-stapled* kinds, as many as 4,000 have been counted in the length of an inch, whilst in the long staples they rarely exceed 2,000, and are often not more than 1,200 in number.

Now, if we take a few hairs not possessed of these qualities, human hair for instance, and twist them together, we find that they will not retain the twist, but straighten themselves, as soon as the ends are liberated; but a similar number of wool fibres so twisted retain that condition and form a thread. This arises from the fact that the scales hook into each other whenever they are forced into contact, and thus the fibres become inextricably interlocked: this will be the more complete in those varieties in which the scales are most numerous; and the curves will of course aid much, as when twisted they cause the individual fibres to form spirals. Of course, this interlocking would not be so complete if all the fibres were laid in the same direction, but this is practically impossible with wool, as the simplest mode of preparing it is sure to prevent such a result. Therefore, if two fibres come in contact in opposite directions, as in Fig. 5, we see at once what must be the result if they are twisted—the scales of one will slip under or over those of the other, and they will be thus held together. If the twisting has only been done slightly, the scales will only be held by their points; if much twisted, the scales will be inserted under one another as far as they can go. In the former case the length of the thread produced will not be much less than that of the fibres employed; in the latter it will be much shorter.

There is one still more minute quality in these scales, which is not generally noticed, but it is of very great importance; it is that the under side is not perfectly smooth, and this offers some resistance to the interlocking of the scales. This is proved by the fact that when a lubricating fluid like soap and water is used, the interlocking is rendered more complete and permanent.

This peculiar property of wool is called *felting*, and it will be seen that this causes the shrinkage of woollen clothing when washed; the rubbing, the soap and water, and the wringing, are all operations which are sure to make the fibres of wool work together to the fullest extent they are capable.

So remarkable is this property of felting, that with many kinds of wool it is only necessary to mingle the fibres, wet them, and beat them gently, to get them to combine and form a fabric, which is used in various ways for clothing, under the name of *felt*, which will be hereafter described.

So far, sheep's-wool has been the type before us, because no animal produces wool so perfect in all its essential qualities; indeed, so perfect is it, that without a full knowledge of the physiology of this most useful of animals, it is a matter of no little wonder that the immense mass of wool which constitutes the fleece of a single sheep, does not, from the movements of the animal and other causes, felt into a compact mass upon its back. We find, however, a provision in the economy of the sheep which secures it from such an evil.

A large portion of the skin of the sheep exudes a secretion known by the name of *yelk*, which is a kind of natural liquid soap, as it contains both oil and the alkali potash. This lubricates the fibres, which on the skin of the animal are all held in one position; hence, they are kept freely moving upon one another during the motions of the animal, and do not, consequently, *felt.* So abundant is this secretion, and so large the amount of alkali present in it, that it has been suggested that the waters from sheep-washings should be used as a source of potash; and at the Cape of Good Hope and in France, this valuable and not very abundant alkali has actually been recovered with profit from the water in which sheep have been washed.

Most animals which are clothed with hair have two kinds: one smooth and unprovided with the scales which distinguish wool; the other, usually the undergrowth, which either has such scales or some modifications of them. The latter is called either *wool* or *fur;* the term *wool* is, however, very limited in its application, whilst the number of fur-bearing animals is very considerable. For technical purposes, it is convenient to dis-

tinguish them thus:—*Wools*, those animal fibres which can be both spun into yarn and also felted. *Furs*, those which can only be felted.

The true wool-bearing animals are the sheep, the Cashmere goat, the alpaca, the llama, the guanaco, and the camel. As no animal in an absolutely wild state produces wool in such abundance as these, there is some reason to suppose that it is largely due to the changes produced in the animals by domestication. The guanaco might almost be excepted, for it is so wild that it has to be hunted; nevertheless, it yields an inferior kind of wool used only by the Indians and Mestizos of Peru.

The chief of all wool-producing animals, the sheep, is so remarkably connected with the history of man, that no fossil remains of the animal have ever yet been discovered which are not clearly referable to times coeval with the human race; at least, this is the case with respect to Europe, and leads to the inference that it has been introduced from some other part of the world by man in his migrations. And it is equally interesting to find that it is associated with the history of our race as far back as any historical records exist, and this association is due to the use of the animal both for food, and in furnishing materials for clothing. Throughout the Old Testament, allusions to the rearing of sheep and their uses continually occur, and they are equally numerous in the old classical writers, from whose writings we gather that, from the earliest times, a pastoral life was common to all the inhabitants of Persia, Mesopotamia, Syria, Palestine, and Arabia, and extended into Scythia and Tartary. Indeed, there is no want of evidence to prove that the culture of the sheep for its wool, as well as its flesh and milk, was common throughout the greater part of Asia Minor and Scythia before Greece planted its colonies in those districts; and in very ancient Græco-Scythian antiquities discovered on the site of the colonies of Panticapæum, representations are found showing the highly pastoral character of the people, and the perfection of their woven clothing, which was doubtless of wool.

The Greeks and Romans, from the commencement of their respective histories, were familiar with the wool of the sheep, and reared varieties of different qualities. The wools of Miletus and of Phrygia were famous for ages, and form themes for their historians and poets; and so famous were the fleeces of the Attic sheep, that the shepherds covered them with skins in bad weather to preserve and improve them, whilst the district of Arcadia has obtained an immortal celebrity for its pastoral life. Moreover, from the times of the most ancient Greeks to the later Romans, the trade in wool was considered under the especial protection of Mercury.

Amongst the Romans wool was held in high esteem, and various breeds had great celebrity—a celebrity which exercised the pens of their most famous writers. Virgil and Pliny, Varro, Tertullian, and Columella, have all left abundant evidence in their writings that the subject was considered worthy of such celebrated writers, and that the shepherd's life was regarded with great favour in their days; for we cannot class their writings with those of the poets of our own country, who make the pastoral life the basis of many of their amatory songs and poems.

But however abundant the evidence of the use of wool, and consequently the rearing of sheep, by the nations of classical and Biblical antiquity, we are entirely without information respecting the introduction of the sheep to Britain. As before stated, the negative evidence of the absence of true fossil remains forbids the assumption that the animal was indigenous; and although assertions have been made that sheep were introduced by the Phœnicians, that wonderful people who are made to account for so many difficulties, yet there is no actual proof that our forefathers had seen the sheep when Cæsar landed on our shores, or for a hundred years afterwards. In all probability, we are indebted to our conquerors for this useful animal, and we certainly are for the first establishment of a woollen manufactory, which was founded at Winchester in the time of Agricola. From that time we know from various sources that the trade flourished, and that it also became a female accomplishment of the highest character (whence the term *spinsters*) to work the wool up into fine yarns, and even to weave it into garments; whilst those men who were engaged in rearing sheep, although sometimes called shepherds, were held to be persons of distinction, and their daughters could mate with kings, as in the case of King Edward I., whose first wife, Egwina, was the daughter of a shepherd; and the princesses his daughters were skilled in spinning wool. In subsequent papers will be given the various methods employed in those primitive times, as well as at the present, for preparing the wool for the various purposes to which it is applied.

Next in importance to the wool of the sheep is that of a species of goat (*Capra hircus*), a native of Cashmere and the elevated table-lands of Thibet, where it thrives at an elevation of from 12,000 to 16,000 feet. It also abounds in the mountainous districts of Asia Minor, and one of its varieties is reared in vast numbers in the neighbourhood of Angora, whence it is called the Angora goat, the fine, long, silky hair or wool of which forms a very important article of commerce, so much so that the imports to Great Britain alone represent an annual value of over half a million sterling. The greatest quantity comes to us from the various ports of Turkey, from which alone we receive the enormous quantity of between nine and ten thousand tons annually.

In ancient times we know that the common goat, the European variety, was shorn of its hair, which was manufactured into various textile fabrics of the coarsest description, such as sailors' clothing, coverings for tents, and especially for such coarse bags as we now call sacks; in fact, we derive the word sack from the Hebrew name of goat-hair cloth, which was *shac* or *sac*. From the fact that the Romans obtained the best goats'-hair from Cilicia, cloths made from it were also called Cilicias, and we still use the term slightly altered for a class of fabrics made from sheep's-wool. The fine wool yielded by the goat of Cashmere and Thibet, and the beautiful material which, combining the qualities of wool and hair, is yielded by the Angora goat, were both unknown to the Greeks and Romans, and our acquaintance with them is comparatively very recent. Fifty years ago the imports of this material only amounted to a few hundredweights per annum, and it was not until many important modifications in the machinery for spinning it had been perfected, that it attained to the great importance which it now has in our manufactures, under the name of mohair. The wonderful improvements which have been made in that time in carding machinery, have led to a vast extension of the trade in mohair, and to the use almost equally extensive of another beautiful wool, that of the alpaca (*Auchenia pacos*) and its allied species (*A. llama* and *A. huanaco*). These animals are natives of the Peruvian Andes, where, besides two of them being useful as beasts of burthen, they all yield a peculiar kind of wool which, besides being very long, is exquisitely soft, and beautiful in lustre. In the time of the Incas beautiful cloths were made from the wool of these animals, specimens of which are still occasionally found in their tombs; but it was not until about 1840 that its usefulness was fairly recognised in this country. Now the annual importation is over three millions of pounds, and the value nearly half a million sterling, giving employment to many thousands of people in the production of beautiful fabrics, which will be more fully described in a subsequent paper. The only other animal which yields hair which has the properties of wool, and is used as such, is the camel. This creature is ordinarily covered with a thick coating of soft brown wool, amongst which are sparingly mixed long smooth hairs. When these are separated, they are of great use in the making of small paint-brushes for artists, and the wool can be spun and woven into cloths of beautiful quality, as to softness and durability. Eastern nations use it extensively, but it has not been employed in Europe, except in Russia, where it is in great favour for military clothing, and is as much in fashion as the scarlet woollen cloths are in our military service.

Besides the true wools, and those varieties of hair which also have the properties of wools, all the true furs possess the property of *felting* in a remarkable degree; they are very numerous, but only a few of them are sufficiently abundant and cheap to be used in making textile fabrics by the process of felting. Chief amongst those which are so employed are the hare and rabbit, called in commerce coney-wool; the beaver, though very little, compared with its former extensive use in the manufacture of hats; the musquash (*Fiber Zibethecus*); the nutria or coypu (*Myopotamus coypus*). These materials are very extensively employed in the manufacture of felt hats, usually, however, in a state of mixture with sheep's-wool. In

the next article on woollen manufacture will be described the fabrics made from these materials in the earliest times, as an introduction to subsequent papers on the modern manufactures.

CAPITAL AND LABOUR.—IV.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

CAPITAL AND WAGES.

There is a very general opinion that the amount of wages procurable by those who labour depends on the amount of capital which is capable of being employed in the payment of wages, and some writers have thereupon discovered what they have called a labour-fund, meaning by this the quantity of property in the hands of those who employ labour, concluding that this property is the sole cause why labour is employed at all. It is further imagined that as this fund increases and diminishes, so the condition of labourers is bettered or made worse; and a quantity of ingenious reasonings have been propounded, and a number of ingenious precautions suggested, which have for their object the sustentation of this labour fund, and the prevention of those direful consequences which might be expected to ensue, were the fund curtailed, or rendered less manageable for the purpose to which it is to be devoted. If, however, we are able to show that this labour-fund is a mere creation of fancy, which has no reality, all these alarms will be shown to be as baseless as their object is.

There is always a foundation of truth in any wide-spread delusion. The truth may be very small, and it may be used for the development of such vast errors, that it may become mischievous by its incidental or inveterate connection with these errors, and thereby it may do much more harm than good. In the matter immediately before us the truth as to the relations of employer and workmen is that the manifest convenience of such relations is so considerable that they are frequently supposed to be all important. Again, any interruption of these relations brings about so serious an inconvenience that people may well be pardoned for exaggerating the significance of such facts as really exist. For example, the wide-spread distrust which prevailed for some months after May, 1866, when an eminent house of business in London was proved to be wholly bankrupt, was so serious, that infinite injury was done to every branch of industry by the recklessness and deception of the persons referred to. People did not know on whom they might rely, and in consequence business was paralysed; for credit is so very delicate an instrument, that though it is capable of most astonishing feats of power, it may be deprived of all its energies and collapse.

Labour is not set in motion by the property of the employer, but by the demands of the public. Houses are not built, cloth is not woven, books are not printed, because builders, spinners, and printers have property, but because the public is prepared to purchase each of these articles. If no such desire existed on the part of the public, the property of employers would cease to be productive, and the action of employers would cease. This position is so plain that it needs only to be stated in order to be immediately acknowledged and admitted. No industry can exist or continue unless the public requires the product on which the industry is exercised. Nay more, if for some reason the product in question may be obtained more cheaply and conveniently from some other source besides that which has hitherto supplied it, and the public is allowed to obtain it from that source, the industry which is now made less effective will be discouraged, and, unless it can accommodate itself to the altered circumstances, will finally come to an end. However abundant the property of the employers may be, nothing but public demand can keep an industry alive.

Now the capitalist employer, when such a demand exists, performs two important services. He interprets or measures the extent of the demand for the object in which he trades (not always exactly, for he frequently produces too much, and may produce too little of the article), and he keeps the price of the article pretty steadily up to the cost of producing it. Much time would be lost if the workman were seeking the customer or consumer of the article which he produces, and much labour would fail of occupation were there no person who found out, as his proper business, the means for bringing producer and consumer together. Again, the workman has constantly very little beyond his labour to sell. If he employed himself on producing articles which he took to market himself, the price of that which he makes would be liable to sudden and frequent changes, as his necessity forced him to sell, and the wants of the customer were unsatisfied. Now there is nothing which a producer desires more than as uniform a price as possible for that which he makes. It is this result which the employer brings about. He is able to hold goods back from the market, because by the possession of his property he can wait till a fair price can be obtained for the article in which he deals. His position, then, is essential towards the true interpretation of public demand and its regular supply. But he does not set the labour in motion. This result is obtained because the labour can do something which is useful, and so will be purchased or employed.

The employer, then, buys labour, which he sells again, either by hiring out the labourer to the customer, or by disposing of those articles in which labour has been condensed. Sometimes the service which he does to the labourer in relation to the two points just adverted to is very slight. For instance, the master baker has probably sold, and has been paid for the service which his journeymen perform long before he has paid them for the work which they have done. But in the great majority of cases the work of the labourer is paid for some time before the price of the work has been recovered from the public. Occasionally the work or service to be performed is of such a character that a very large sum has to be laid out, and laid out permanently, before any payment can be obtained. The cost of constructing a railway is very great, and must be incurred before any charge can be levied for the conveyance of passengers and goods. Were it not for the capital of the employer—*i.e.*, of the railway shareholders, acting through the managers or directors—no service whatever could have been done. The shareholders have rendered it possible that workmen should be employed in rendering the service. But when the road is laid down, and the carriages and engines are supplied, the trade of the shareholders is characterised by even more rapid returns than that of the baker referred to above. The railway receives the payments for passengers and goods long before it pays those persons whom it hires to do the work for the public. In other words, after the first outlay, the demand of the public finds the means for paying the wages of the railway servants to a far more notable extent than is the case in any other trade.

The inaccurate and unphilosophical language often used about the relation of labourer and employer, under which the former is made to appear as though he owed his employment and subsistence to the latter, has led to very serious inconveniences, for it has constantly estranged workmen from their employers, and has given an impression that the relations between them are those of patron and dependent. Rightly considered, there is no more dependency between the two than there is between the miller and the farmer. In order that a farmer may sell his corn it is no doubt necessary that the miller should be at hand to buy and prepare it for the public. But similarly, in order that the miller should set his mill going, it is necessary that there be a farmer who shall supply him with corn to grind; and much more important still, neither the farmer would find a market, nor the miller get his living, unless the public were prepared to use the corn of the one, and employ the services of the other.

The employer, then, is a dealer, or go-between. His real value in the economy of society is not disparaged by pointing out what his true position is, and by stripping it of those pretended powers which it never possessed, and never could assume, if its real meaning were investigated. Like every other person who gets employed, he has a use, and a very important one. He would not, indeed, occupy the position which he does, if there were not a notable use in the office which he fills. But like the labourer whom he employs, he is paid for his labour, and because his labour is acknowledged to be useful. Similarly, just as any kind of manual labour may be superseded if some machinery may be found to supply its place, so it is possible that the office of the employer may be superseded, if a better and cheaper substitute can be found for it. I say *possible*, for as far as human understanding can determine, the relative conditions of employer and employed will exist, like rich and poor, as long as the world lasts.

TECHNICAL DRAWING.—LXXVIII.

DRAWING FOR CABINET-MAKERS (*continued*).

THE first example given in this lesson (Fig. 610) represents a small mahogany wardrobe, drawn to the scale of $\frac{3}{4}$ inch to the foot. It consists of a drawer and two compartments, the one of which may be fitted with trays and the other arranged for hanging.

In commencing to draw this object, erect the central perpendicular, and draw the ground-line. Set off on each side of the perpendicular, A, half the width of the plinth, the entire width of which is 3 feet 6 inches; and at these points, B and C, erect

The bead covering the meeting of the doors is now to be drawn, half its width being set off on each side of the centre line. Within the two rectangles thus formed draw the panels. It will be seen that the curve uniting the top with the sides of the panels is a quadrant, the centre of which is at *a*.

Fig. 611.—The next example here given represents a small bookcase with closets at bottom, drawn to the scale of $\frac{3}{4}$ inch to the foot.

Above the closets is a drawer for music, manuscripts, etc. The top of the lower case projects on the front and sides, and is moulded with a quarter-round and fillet. The moulding of the cornice is the *cyma recta* (Fig. 116, Vol. I., page 200).

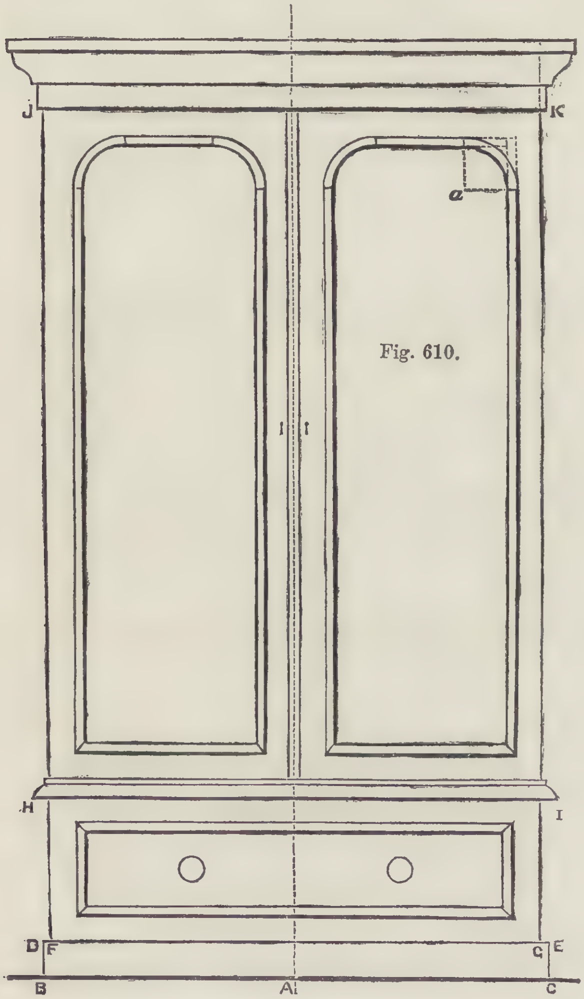


Fig. 610.

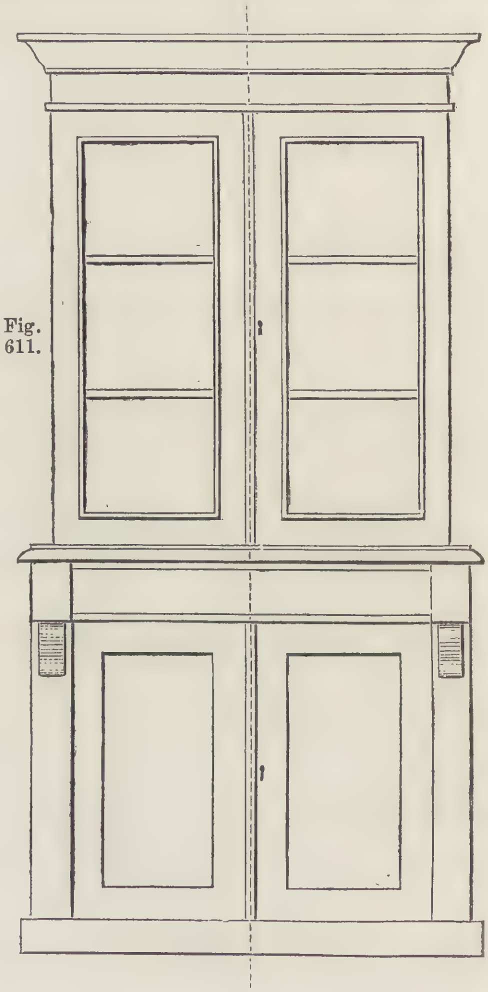


Fig. 611.

perpendiculars 3 inches high. Join these by the horizontal line D E, the upper line of the plinth.

Now the width of the body of the wardrobe is 3 feet $4\frac{1}{2}$ inches, the plinth projecting $\frac{3}{4}$ inch in the front and on the two sides. Having set off half this measurement on each side of the centre line, draw the perpendiculars F and G: these may be indefinitely high, as they form the sides of the entire wardrobe.

Draw the horizontal line H I, for the lower line of the small cornice which separates the drawer from the closets above. This projects 1 inch on the front and sides, and is $1\frac{1}{4}$ inch thick, including the fillet. The height of the closets is 4 feet 10 inches to J K, and the entire cornice is 6 inches high.

Draw the horizontal line J K, and the others required for the cornice, which may then be completed. It will be seen that the moulding is that shown in Fig. 120 (Vol. I., page 200), viz., the *cyma reversa.*

The measurements of this object may be obtained from the example, the method of drawing which is so precisely similar to the last that no further directions are deemed necessary.

PERSPECTIVE FOR CABINET-MAKERS.

The subject of Perspective is one of much importance to the cabinet-maker. We do not mean that this particular branch is used in the workshop; there, Practical Geometry and Projection form the fundamental methods by which the working drawings are made, whilst freehand drawing, of course, occupies in the ornamental portions of the trade a very high position.

By means of Perspective, however, drawings of the various articles of furniture are made in order to enable the customer to judge of their appearance, and it will be easily understood how, in a business point of view, the power of making such drawings may benefit the artisan, and how valuable to his employer a man may become, who, when calling on a customer, is

able from his oral description, to sketch out the article on the spot, in such a manner that the artist employed in the establishment can make a finished drawing, from which the working drawings are subsequently to be made. And, further, by means of a practical knowledge of model drawing, which is the freehand application of perspective, a young workman who carries with him a small sketch-book and pencil may lay up a store of sketches, which will be invaluable to him on a future occasion.

As Perspective is treated of in a separate series of lessons, to which (Vol. I., page 292 of THE TECHNICAL EDUCATOR) for details of the principles the student is referred, we here proceed to show the application of these principles to the special branch of trade which forms the subject of the present course.

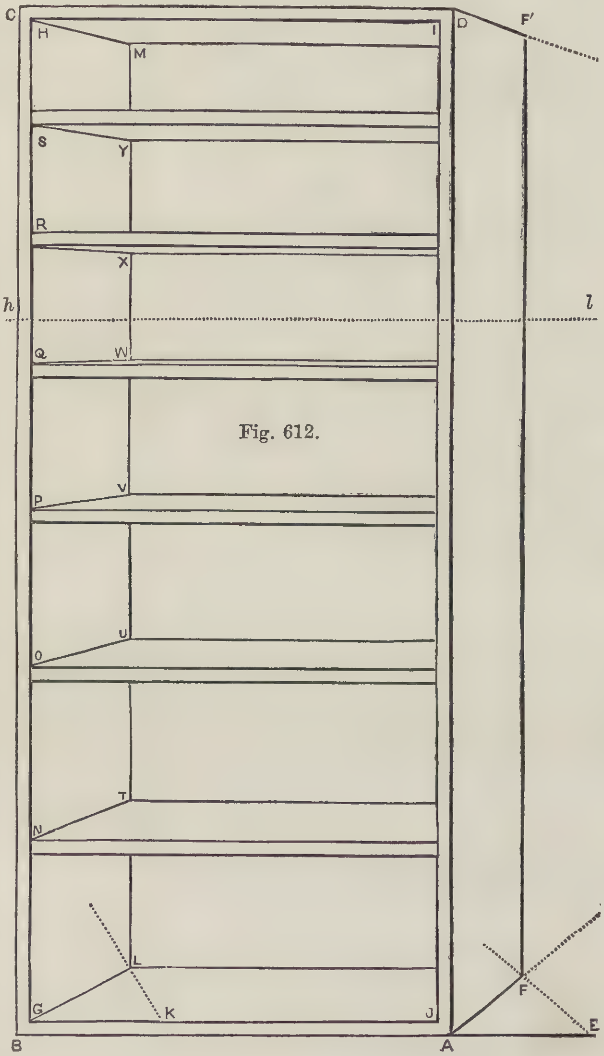


Fig. 612.

A mere glance at the earlier lessons on "Practical Perspective" will therefore suffice to remind the student who has gone through them, of the general principles; and having done this, he can at once proceed to the advanced studies. He is, however, urged not to be content with this, but to take up the subject as a separate study, of which he will find the advantage as he proceeds with the other branches of his art. Indeed, it may be said that the workman, however expert and ingenious he may be in the use of his tools or implements of his craft on the one hand, and in forming contrivances for facilitating his work and imparting to it stability of form or beauty of structure on the other can never consider himself entitled to be classed among those who are at the head of their vocation until he has acquired a knowledge of perspective, which is not only the foundation of success in the higher walks of art, but the basis also of well-doing in all the vocations, be they what they may, to which the art of drawing is ancillary.

Fig. 612.—The subject of the present lesson is a rack of book-shelves, drawn to the scale of $\frac{3}{4}$ of an inch to the foot.

The external width of this case is 3 feet, and the total height is 7 feet 1 inch, made up as follows:—

	Inches.
The top, bottom, and six shelves, made of wood 1 inch thick	8
The 1st space from the bottom	14
" 2nd " "	13
" 3rd " "	12
" 4th " "	11
" 5th " "	10
" 6th " "	9
" 7th " "	8
	85 in. = 7 ft. 1 in.

Having, therefore, drawn the rectangle bounding the front of the entire case—viz., A B C D (3′×7′ 1″)—mark the point of sight and the point of distance.

Now the height of the spectator is supposed to be 5 feet, and thus the horizontal line (h l) is to be drawn at that distance from the picture line, and as the object is to be represented as standing at 6 feet on the left of the spectator, the point of sight is to be set off on the horizontal line at that distance on the right of the perpendicular, A D. The distance of the spectator—viz., 11 feet—is then to be set off from the point of sight on the horizontal line on the other side of the object.

In order to economise space these points are not placed within this figure.

The depth of the case externally is 1 foot. To show this, draw lines from A and D to the point of sight, set off 1 foot on the picture line from A—viz., A E—and draw a line from E to the point of distance, cutting the line drawn from A to the point of sight in F. At F erect the perpendicular F F′, which will be the back line of the case, thus rendered as a mere block.

The thickness of the wood of which the entire case and shelves is made is 1 inch, and this is now to be represented by the inner rectangle G H I J.

The interior of the case next claims attention, and to project this draw, in the first place, lines to the point of sight from G and H.

Now it will be remembered that to obtain the depth of the case *externally* 1 foot was set off from A—viz., A E—and a line drawn from E to the point of distance, intersecting A, gave the point F, the place for the distant perpendicular F F′.

The same system is now to be pursued; but the *interior* depth is 1 inch less than in the previous case, the back of the case being made of wood 1 inch thick; therefore,

From G set off G K (11 inches by scale), and from K draw a line to the point of distance, which, cutting the line drawn from G to the point of sight, will give the point L. From L draw a perpendicular, cutting H in M; from L and M draw horizontal lines, which will complete the representation of the carcase of the case, the shelves only remaining to be drawn.

On J I set off the respective heights of the spaces and thickness of the shelves, and draw horizontals, giving the front edges of the shelves.

It will now be evident, that as some four of the shelves are below the horizontal line, their upper surfaces will be seen, whilst of the two which are above the level of the eye of the spectator, the under side will be visible. Therefore from N, O, P, Q, R, and S, draw lines to the point of sight. From the points where these cut the perpendicular, L M, viz., T, U, V, W, X, Y, draw horizontals, representing the distant edges of the shelves, and the drawing will thus be completed.

The learner need scarcely be told that as the figure under consideration affords a correct representation of the rack of bookshelves only according to the point of sight and point of distance that has been used in this case, it will be a useful exercise for him to vary these points, and so form a series of representations of the same object from different points of view.

FARMING AND FARMING ECONOMY.—XVI.

By Professor Wrightson, Royal Agricultural College, Cirencester.

MANAGEMENT OF CATTLE.

DIVISIONS OF THE SUBJECT—TERMS EMPLOYED—ADAPTATION OF BREEDS TO THEIR LOCALITIES—MANAGEMENT OF THE CALF—OF YEARLINGS—OF TWO-YEAR-OLDS.

Cattle management may be divided into three branches—breeding, rearing, and fattening. Occasionally they are followed separately, but more usually are practised upon one and the same farm. The occupiers of high-lying moorland or of mountainous tracts raise "store stock," which are purchased by the graziers of the richer and lower grounds. Hence in this case there is a division of labour between the breeder and the beef manufacturer; but more commonly the ordinary farmer keeps a few cows and brings up a lot of calves every year, which eventually find their way into his feeding stalls.

Cattle are classified according to sex and age. All are spoken of as horned stock, neat cattle, and beasts. Calves are either *bull calves* or *heifer*, *quey*, or *cow calves*. Yearlings of either sex are called *stirks*. Subsequently they are spoken of as *two* and *three year old bulls*, *steers*, or *heifers*. The female is called a cow after she has dropped her first calf; the male, if castrated late in life, is termed a *stag*, and the castrated male or *steer* becomes a *bullock* or *ox* when he has arrived at the age of four years. Such are the terms by which cattle are usually designated on the farm and in the market.

The selection of a breed of cattle is usually decided by the previous experience of the neighbourhood. As a general rule, worthy of the gravest consideration, there is an adaptation in the case of every breed to the soil and climate of the district over which it has spread. This remark is applicable to sheep as well as cattle, and attempts to rashly introduce new breeds of either into a district often fail. The hardy West Highland cattle and black-faced sheep exactly suit the severe circumstances under which they exist; the heavy Lincoln and Romney Marsh sheep require the flat luxuriant pastures upon which they graze; and the shorthorn requires rich meadows and liberal management to maintain him at perfection. The fact that a race of animals exists in a locality is a strong argument for its continuance. Safe and reasonable as is the opinion above stated, notable exceptions to its truth might be given. Thus, the shorthorn has made his way to the detriment of many native established breeds. The Leicester and Shropshire sheep have supplanted many of the older ovine races, and at the present day there is a tendency for certain dominant and improved races of live stock to intrude into districts up to this time occupied by native breeds. All we demand is caution, as sweeping and ill-considered changes are liable to end in loss to the too-enterprising agriculturist.

CATTLE BREEDING

may be divided into the breeding of high-bred or pedigree stock and the breeding of good useful cattle intended for the production of beef and milk. The first division represents the breeding of animals with the object of improving the race generally; and the second, while it participates in the improvements effected by the first, has for its object the immediate supply of the consumer. In the first, a perfect form, fine quality, and unspotted lineage are essential; in the second, a "good sort" is all that is asked for—cows which give plenty of milk—healthy, growing young stock, and steers which will yield a good return for the food they consume. Such animals are very frequently the produce of ordinary "useful" cows and pure-bred shorthorn bulls. We have already given sufficient space to the principles of breeding pure-bred stock, and we now turn to the management of more ordinary cattle, such as are to be met with on all well-managed mixed husbandry farms.

The calf is affected, previous to its birth, by the treatment of its mother. Cows should not, therefore, be milked when within six weeks of calving, if we wish to obtain well-nourished and well-grown calves. This first precaution having been enforced, we shall, without entering into all the difficulties incident to parturition, suppose the calf to be naturally ushered into the world. This important event usually takes place in the spring. Calves are dropped at all seasons of the year, but many reasons may be given for preferring the spring for this purpose. First, the young animal has the summer before it, and will have gained sufficient strength previous to winter to enable it to stand its rigours; secondly, the mother is brought into the best condition for yielding milk just when grass is most abundant. Where the farmer supplies the demand for new milk, he requires cows to calve at various seasons of the year; but where cheese is the staple produce of the dairy, summer is the only time during which the manufacture proceeds briskly.

The subject of bringing up calves is one on which much might be written, but our space being restricted, we are necessarily compelled to treat it with brevity. What, then, is the method to be adopted? We may allow the calf to suck its dam, a plan which has the recommendation of being natural; we may teach the calf to drink, and bring it up by hand on new and old milk; or we may adopt the system of feeding upon substitutes for milk, such as gruel or mucilaginous substances. Each of these plans has its advocates, and each must detain us for a short time. The writer objects to the first plan, unless in the case of high-bred stock, or of cattle which are intended to be forced forward from their birth and fattened at a few months old. Under any other circumstances this method is open to the following objections:—The quantity of milk the calf receives cannot well be controlled; the diet exclusively consists of new milk, and the thrifty farmer is debarred from introducing any other cheaper material, such as Iceland moss, linseed mucilage, and gruel, all of which are excellent foods for young calves. We must also remember that, where the land is poor, and where the yearlings and two-year-olds have to do as well as they can upon somewhat bare pastures, it is very questionable policy to pamper calves, and thus unfit them for the hard life which lies before them.

These considerations clearly point out the expediency of limiting the amount of new milk, and this can only be done by bringing the calf up by hand. Immediately the calf is born, it is removed to a suitable hutch or crib, and rubbed dry with straw. It should receive its first meal immediately after this operation, and during the first day it should be fed every four or five hours. The meals are speedily reduced to three, and afterwards to two per day, until weaning time. A calf requires to be taught to drink. Its natural inclination to suck is satisfied by placing one or two fingers of one hand in its mouth, while with the other hand the head is lowered, by gentle pressure on the crown, into a vessel containing milk, until the mouth of the animal is immersed. The sucking proceeds, and by gradually withdrawing the fingers, the calf is soon taught to drink. A very young calf is for this reason sometimes spoken of as a "finger calf." The following dietary for calves from birth to weaning is employed upon a well-managed farm in Northumberland with great success:—

1st day . .	1 pint of new milk every $4\frac{1}{2}$ hours.		
2nd day . .	2 pts. in the morning;	2 pts. at noon;	3 pts. at night.
3rd day . .	3 ,, ,,	3 ,, ,,	4 ,, ,,
4th and 5th days,	4 ,, ,,	2 ,, ,,	4 ,, ,,
6th and 7th days,	5 ,, ,,	2 ,, ,,	5 ,, ,,
8th and 9th days,	6 ,, ,,	0 ,, ,,	6 ,, ,,
10th to 30th days,	8 ,, ,,	0 ,, ,,	8 ,, ,,
2nd month . .	8 (old milk) ,,	0 ,, ,,	8 (old milk).
3rd month . .	8 (old milk) ,,	0 ,, ,,	8 (old milk).

Eight quarts per day is thus the maximum amount of milk given, and the increasing appetite of the growing animal is satisfied by grass, hay, finely-chopped turnips, meal, ground cake, etc., which it soon begins to relish if they are properly introduced to its notice. Mr. Bowick, manager of Mr. Howard's (Biddenham) farm and herd, in an admirable essay on calf management, gives the following allowances of milk as requisite for calves:—

1st week, with the dam, or 4 quarts per day, given in two meals.
2nd and 3rd weeks—5 to 6 quarts, given in two meals.
4th and 5th weeks—6 to 7 quarts, given in two meals.
6th to 12th weeks—8 quarts, given in two meals.

"If really good, creditable beasts are wanted—such as will realise £25 per head from the butcher when turned two-and-a-half years old—a little cake or meal will be found a desirable investment." Further, Mr. Bowick makes the following alterations from new to old milk:—New milk is given the first fortnight; the third week skim milk is substituted to the extent of one-third of the allowance; and at the fourth week the new milk is reduced to one-half, and boiled linseed gruel is added,

five pounds of linseed being enough to provide seven gallons of gruel, and to suffice for five calves. Mr. Bowick recommends the plan of tying up calves, but the more general and healthy plan is to keep them in cribs or hutches in a light, well-ventilated building. The cribs vary in size from 4 ft. × 4 ft., and 4 ft. high, to 4ft. × 8 ft. × 4 ft., and are "sparred" with slips of tile-lath and provided with a small wooden wicket to afford access to the calf. The floors of the cribs may be earth, but the passage between them should be flagged or of asphalte (Scott Burn). Each calf crib must also be provided with a trough and rack.

Mr. Henry Ruck (Cricklade, Gloucestershire) described an excellent plan for bringing up calves with a minimum quantity of milk, which he had successfully carried out for some years. His experience was communicated to the Cirencester Chamber of Agriculture, and was reported in the *Agricultural Gazette* of August 25, 1866. Calves are purchased at ten days old for about 30s. each. For the first three or four days they receive a milk diet, after which their food is gradually changed to a prepared gruel. This gruel is made as follows:—First, seven pounds of the best bruised cake is stirred into two gallons of hot water; next, two gallons of a watery infusion of hay (hay tea), diluted with a further addition of two gallons of water, is added; lastly, seven pounds of mixed meal, formed of equal parts of oat, wheat, barley, and bean meals, and the whole is well incorporated by stirring. More concisely, the gruel is composed of the following ingredients:—7 lbs. of linseed cake, 7 lbs. of mixed meal, 2 gallons of hay tea, and 4 gallons of water. Two quarts of this fluid, with two quarts of water, are given to each calf twice a day, and the young animals thrive well upon it at a cost of from 1s. 3d. to 1s. 6d. per week. The foregoing directions must be supplemented by very careful supervision, a point which is strongly insisted upon by Mr. Ruck, otherwise failure will be the inevitable result. Calves will be out at grass during their first summer. After weaning they may receive a small quantity of artificial food—say 1 lb. of linseed cake: they should be provided with a shed during the hot summer months, and as the nights become cold, towards the middle of October, they will be brought into fold-yards.

MANAGEMENT DURING THE FIRST WINTER.

Too often a starvation system has been followed in the wintering of young cattle. While we discountenance pampering, we certainly recommend a liberal plan of feeding, regulated by the quality of the grass land into which the young stock will be turned the succeeding summer. It would be the height of folly to feed young animals with expensive forcing foods in the winter, and then to turn them into poor bare pastures in the summer. Rather let us keep the future in view, and secure a steady, healthy growth from first to last. The usual system is to place the stirks in a fold provided with a shed; to give them a fair allowance of roots, barley or oat straw, and hay, cake, or corn, according to the liberality of the farmer who owns them. Mr. Ruck recommends 1 lb. of cake, 2 lbs. of crushed barley, cut straw, and pulped mangold as sufficient. Mr. Lawrence, of Cirencester, has given 1 lb. of cake and meal and 15 lbs. of pulped roots mixed with chop (cut straw). These figures sufficiently indicate the quantity of food which may be given. The stirks, meanwhile, should be well cared for, regularly fed, gradually changed from poorer to richer fare, supplied with fresh water, and placed in warm, dry, well-ventilated, quiet sheds. With such feeding and surroundings, every particular of which is of great importance, we may hope to see well-grown, healthy yearlings, ready for turning out to grass in the spring.

MANAGEMENT DURING THE SECOND SUMMER AND SECOND WINTER.

This is simple enough. The second summer the young cattle will be out at grass. The second winter they will again be brought into the yards, and fed according to the purpose for which they are intended. If to run once more on poor land during their third summer, straw and a few turnips will suffice; if to be brought out as "fresh beasts" and offered to the graziers of good land, then they will be proportionately better "done." Straw and about 3 lbs. of rape cake will keep such cattle alive and healthy. The "Farmers' Calendar" (page 46) recommends 1 lb. to 2 lbs. of linseed meal and a small handful of salt to be added to 1 gallon of water and boiled in a copper. The resulting liquid is then poured over chaff, at the rate of 1 gallon to 2 bushels, and this is given to the cattle twice a day. The two-year-old cattle, after their third summer's grass, are generally disposed of at two-and-a-half years old, to be fattened in the winter, and brought out as fat cattle at or about three years old.

THE LATHE.—XI.

By Henry Northcott.

HAND-TOOLS FOR TURNING IN VARIOUS MATERIALS.

The hand-turning tools for soft woods consist of gouges and chisels. The gouge is shown at Fig. 32, and the flat-edged chisel at Fig. 33. With tools of this sort almost any kind of work can be produced when one knows how to use them. They are employed of many different sizes, and sometimes the flat chisels have different angles for more convenient application to the work; but these two tools are the soft-wood turner's most powerful auxiliaries. Indeed, they may be called the only soft-wood turning tools, because they are not only applicable to almost every kind of soft-wood turning, but they are in form, cutting edges, and mode of using, quite different from all other tools employed by the wood-turner. It may sometimes be advisable to use a tool of some other shape; but in all such cases the tools will be similar to those used for turning hard woods, with the cutting angle ground rather more acute. The gouge is used for taking off the first or main portion of the superfluous wood, technically termed "roughing down." An expert workman will very considerably reduce the size of a piece of wood at a single cut, and will raise a heavy shower of shavings which fly in all directions from the tool's edge. He will first roughly and rapidly reduce the article in this way to nearly the required shape, and then with a sharper tool of the same sort, and with more care, will go again over the turned surface, and with a few light cuts leave the whole article very nearly the proper shape and size. The chisel is then carefully applied to the work, and the comparatively rough surface left by the gouge is replaced by the smooth glossy surface of the well-turned article.

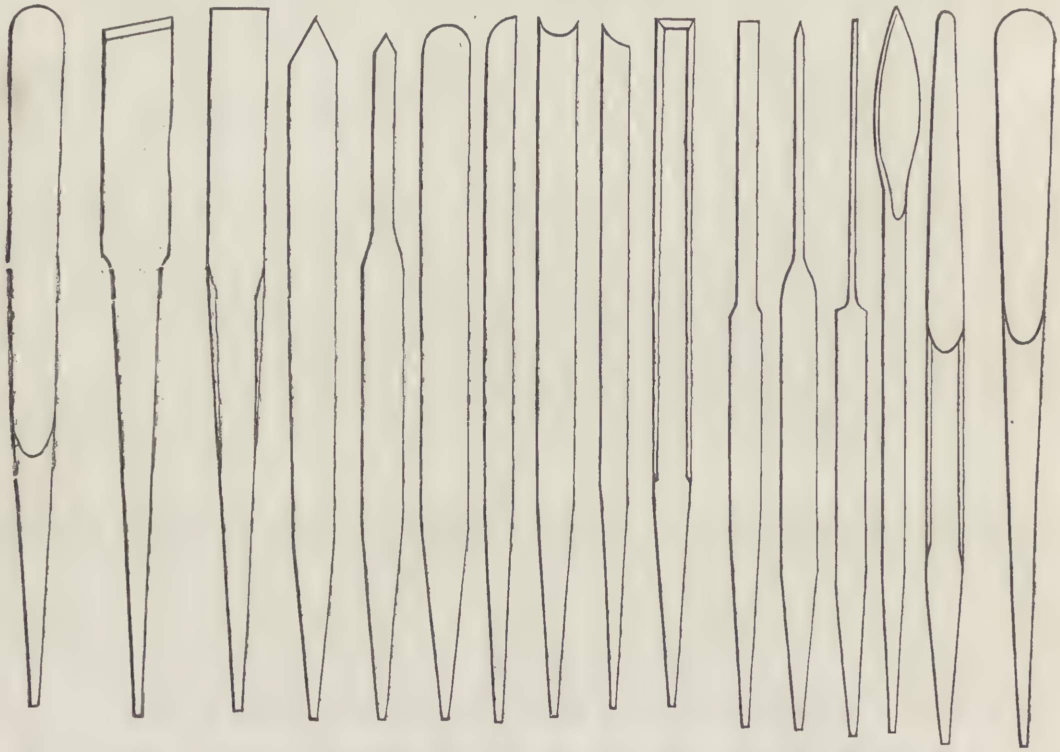
The hand-turning tools for hard woods are shown at Figs. 34 to 70. These tools are nearly all known as chisels, and are only distinguished by the shape of the cutting edge. Fig. 34, for instance, is the flat chisel; Fig. 35 the diamond-point chisel; Figs. 37 and 38 the round-nosed and half-round chisels; and so on with the others. Fig. 34 is chiefly used for turning cylindrical articles; Figs. 35 and 36 for turning angular shapes, corners, and flat surfaces. Figs. 37 and 38 are useful to produce curved forms, round grooves or channels; and Fig. 37 is also generally used for roughing down the harder woods. Fig. 39 is not a very useful tool, because it will only produce one particular form and shape. Fig. 40 is rather more useful. The two last are employed to produce round beads or mouldings. Figs. 42, 43, and 44 are sometimes called "parting" tools. They are useful for very small work, but chiefly for "parting," or cutting off pieces of work from the main cylinder or log. Figs. 45, 46, and 47 are termed "internal tools," as they are chiefly used for turning out holes, and for hollow work. Tools of this sort, but with a keener cutting edge, are sometimes useful for turning soft woods. Figs. 48 and 49 are "holing tools." They act more like drills than turning tools; but they are very useful instruments. Figs. 50 to 54 are chiefly useful for internal work and for side cutting. Some of them cut towards the right, and some to the left, and they are distinguished as right-handed or left-handed side tools according to the direction of the cutting edge. Figs. 55 to 61 are cranked tools, and are very useful for turning internal grooves, and otherwise shaping work not accessible to the straight tools. The hard-wood turner uses them of several sizes, and cranked towards both the right and left hand. Of these tools Figs. 56, 57, 58, and 61 are the most often in request. Figs. 55, 59, and 60 are less useful. Figs. 62, 63, 64, and 65 are also very useful tools. They are employed for turning fancy work, and for touching out corners difficult of access. Figs. 66 to 70 are beading or moulding tools. They are used for producing definite forms or set mouldings upon the turned articles. Any of these forms can, of course, be produced by the ordinary turning tools, and it

is only when many articles of the same shape are required that it becomes worth the workman's while to obtain these special tools for the work. Mouldings produced by these tools are, of course, more correct, and more likely to be uniform, than if the curves were separately turned out with the ordinary tool.

The figures show most of the tools in general use, but many of them may be dispensed with altogether: indeed, it is surprising how few tools some workmen use, and it is very often the case that the largest assortments of tools and instruments are found in the workshops of the least efficient turners. For soft-wood turning the gouge and flat chisels (Figs. 32 and 33) are quite indispensable. For hard-wood turning Figs. 34, 35, 37, 44, 45, 47, 48, 56, 57, and 58 are the most necessary tools. Many of the others are sometimes very useful, but most of them can be dispensed with. For fancy and ornamental turning it is often necessary to have tools made expressly to suit the work, and such tools are generally useless except for such

Most of these tools are used after the same manner, but the efficient use of some of them is much more difficult to learn than of others. The two soft-wood tools are truly cutting instruments. The tools for turning hard woods and brass are scarcely of this class, as their action upon the materials is more akin to scraping than cutting. Some of the turning tools for iron also act incisively. Figs. 71 to 76 are of this class; but the tools used upon cast iron act chiefly as scraping tools. As a rule, the tools which act by cutting are more difficult to use than those that act by scraping.

The gouge and flat chisel for soft woods are held with the cutting edges above the centre of the work, and with the handles of the tools lower than the cutting edges. The hard-wood and brass-turning tools are nearly all held with the cutting edges just level with the lathe-centres, and with their handles also on about the same level. All the tools are supported against the cuts by a tool-rest of some sort, and this



Figs. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47.

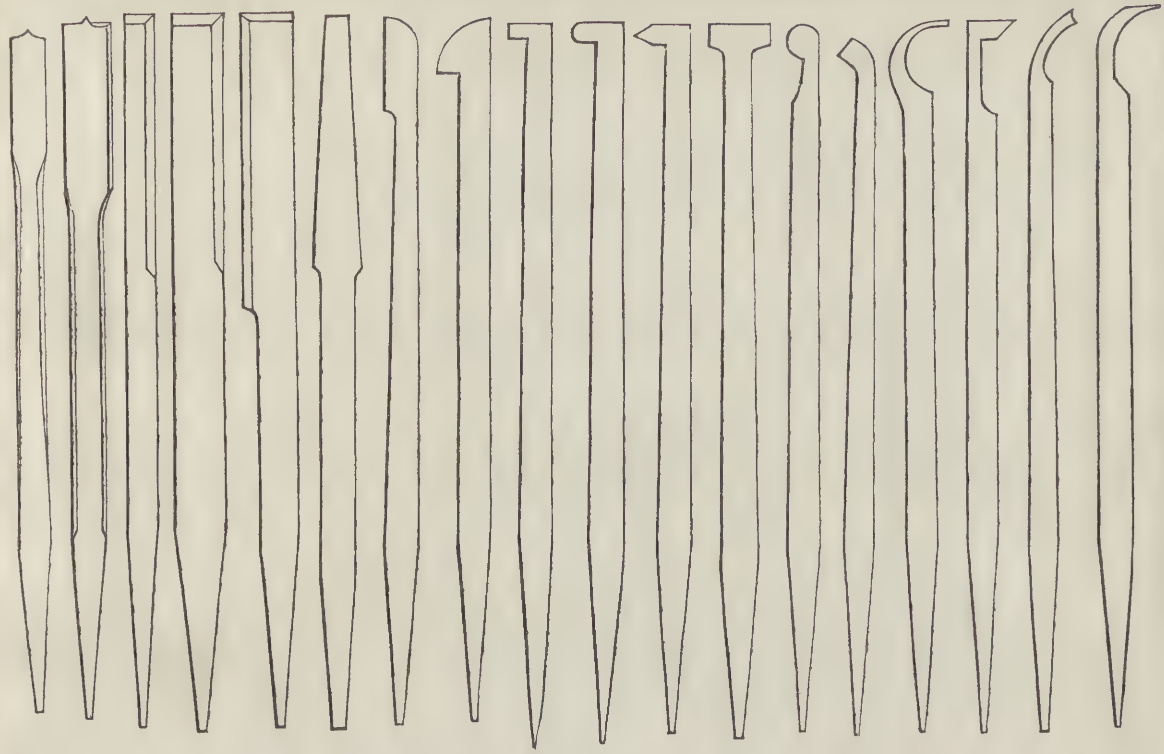
work. Some of these special tools will be illustrated in connection with the work they are designed to effect, and these will be sufficient to indicate how special tools for other work should be formed.

The tools used for turning wrought iron and steel are given at Figs. 71 to 76. Figs. 71 to 74 are used for roughing down the article. Figs. 75 and 76 are side tools for turning ends and side surfaces. The finishing cuts are usually taken by chisels somewhat similar to Fig. 42, but made much deeper and stronger, to withstand the increased strain put upon them.

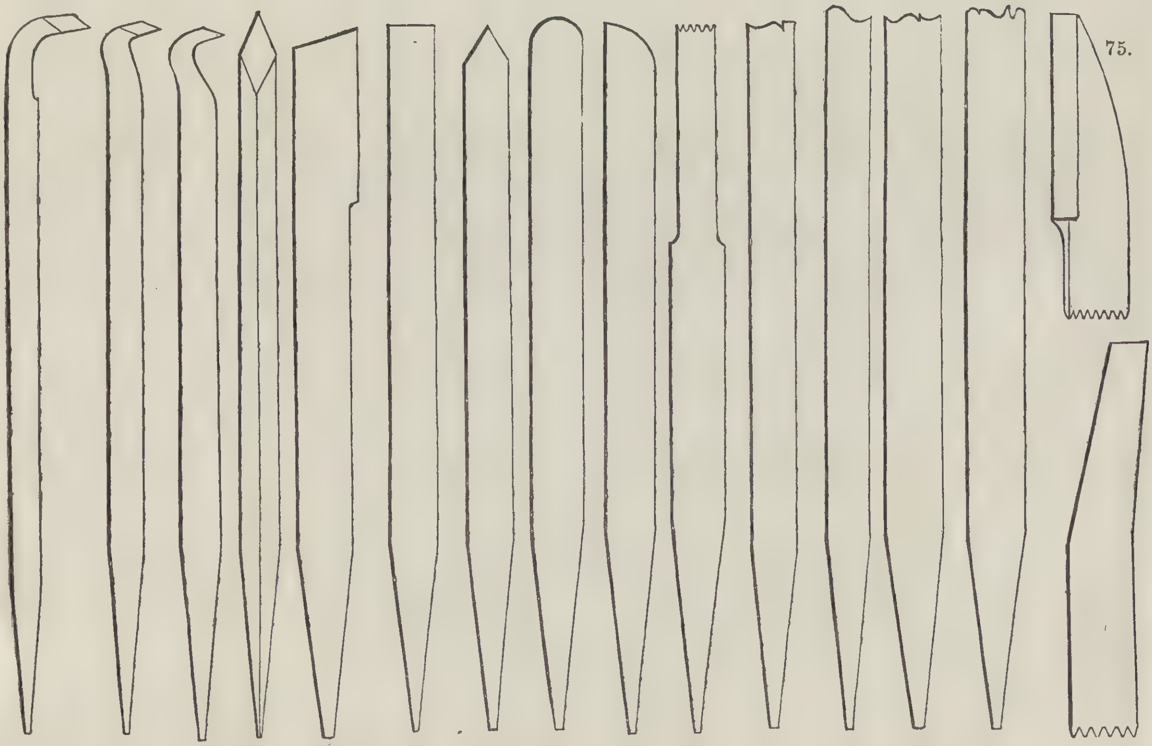
Fig. 74 is also used for taking the roughing cuts off brass articles, and the finishing cuts are taken with the tools shown at Figs. 77 to 81. These tools in outline are much the same as those used for turning hard woods; but the angle of the cutting edge is, in the tools for brass-turning, made more obtuse than in the tools for wood. The blades also are made stouter towards the handle, and the steel is tempered rather harder. In addition to these tools, the brass-turner occasionally requires the use of cranked tools, and special tools of much the same shape as those already given amongst the wood-turning tools, but with a cutting angle adapted to brass, and which is about 90 degrees.

support is generally placed as near the work as possible. The tools are held by both hands, and generally the left hand is employed to guide the edge along the work in the required direction for shaping it, whilst the right hand is employed to regulate the height and inclination of the tool's edge, and the depth of its cut. It should be explained that the term "scraping," applied to describe the action of some of the tools, is, to some extent, an incorrect term, or rather, a term likely to be misunderstood. All of the tools act by cutting the substances they work upon, but in some of them the incisive action is more marked than in others. The chief points to be observed in the use of hand-turning tools are, first, that the tools shall be properly shaped, and kept in good order; second, that the tool-rest or support shall be placed near the work, so as to reduce the leverage acting against the workman as much as possible; third, that the tools shall be maintained in proper position upon the rest, and kept firmly up to their work.

The first point is very frequently neglected even by old hands at turning. The tools are first of all, perhaps, properly shaped and in good order; but as they wear dull on the cutting edge, they are sharpened by removing a small portion of metal near this edge. And as no metal can be removed from the cutting



Figs. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65.



Figs. 71. 72. 73. 74. 77. 78. 79. 80. 81. 70. 69. 68. 67. 66. 76.

edge alone without gradually altering the shape of the whole tool, it follows that the tools in a short time become much injured. The proper plan is to grind the whole cutting part of the tool when *any* part requires grinding; but the keenness of the edge may be maintained by slight applications of the oil-stone.

The position of the tool-rest should especially be attended to by young workmen, as the whole operation of turning is rendered much easier by having the tool properly supported. The steadiness of the tool is chiefly affected by the position of the rest, and to produce good work it is obviously necessary that the tool shall be perfectly under the turner's control.

CIVIL ENGINEERING.—XX.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*concluded*).

We must not conclude our notice of lighthouses without referring to that important subject, the method of lighting them. In order that a beacon may be of value, it is absolutely necessary that it should be visible in all states of the atmosphere, at a distance sufficient to give timely warning to vessels it is intended to warn off from a danger, or direct to a harbour. In ancient times a blazing coal fire was frequently employed for this purpose, or, better still, torches smeared with pitch. But the improvements of modern days have, in the matter of artificial light, far outstripped all the ideas of the ancients. As soon as it became known that combustion depended upon the presence of oxygen, which, as our readers are probably aware, forms more than one-fifth part of the atmosphere, attention was directed to the best means of supplying this gas to the flame. The flame of a common candle receives its supply of oxygen upon its exterior surface alone; but if it were practicable to introduce air into the interior portion of the flame, its brilliancy would be greatly increased. Now this has been accomplished in the case of the Argand burner. This form of burner consists of a circular ring, around which the fuel is supplied. If it is intended to burn oil, the substance usually employed in lighthouses, the wick which abstracts the oil from the reservoir, or which is saturated with it, is made circular, and the thin ring of flame which proceeds from it whilst burning is freely supplied with air upon its interior as well as its exterior surface. A glass chimney is placed over the flame, by means of which the combustion is rendered more complete.

If gas be employed, it is supplied through holes pierced in the ring, and in doing so it is necessary that the holes should be placed at equal distances, and be equal in diameter. The size of the holes is an important point, for if they are too large the gas will flow so rapidly that it will not mix in the proper proportion with the atmospheric air to render the combustion complete, and the result is that a quantity of smoke or carbon is produced, which affects the brilliancy of the light. If, on the other hand, the holes are too small, the gas will not flow in sufficient quantity to produce the necessary quantity of light; it is also generally observed that the burners which contain the greatest number of holes within a certain space afford the most brilliant light. A few rules founded on observation may not be out of place. The rings of burners which have 10, 15, 20, or 25 holes, should have their diameters respectively $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{5}$, and $\frac{13}{20}$ of an inch; the breadth of the rim being $\frac{12}{100}$ of an inch. The height to which flame may be raised without smoking is as follows:—If with 8 holes, 4 inches; 10 holes, $3\frac{1}{2}$ inches; 15 and 20 holes, $2\frac{1}{2}$ inches; and 25 holes, 2 inches.

The most economical, and at the same time the most brilliant light from common gas, is produced by a burner in which the jet-holes are very numerous, the aperture for admitting air small, and the diameter of the chimney narrow; and when several jets are combined, as in the Argand burner, the light increases in a greater ratio than the expenditure of gas. The chimneys for the burners mentioned should be respectively $\frac{8}{10}$, $\frac{12}{10}$, $\frac{13}{10}$, and $\frac{15}{10}$ of an inch in diameter, and 6 inches high. The equivalent of light obtained from sperm oil and gas is as one gallon of the former to 29 cubic feet of the latter, both being pure, and both being utilised to the utmost. The presence of sulphur in gas as sulphuretted hydrogen is detrimental to the purity of the light produced by its combustion; this is readily detected by passing a stream of it through a solution of acetate of lead. If sulphur be present, a black precipitate or a dusky hue will be produced in the solution; if the gas be pure, the colour of the solution will be unchanged. The necessity for producing a brilliant light in the lantern of a lighthouse will be obvious, from the fact that light diverges in every direction from its source, and that its intensity decreases in proportion to the *square* of the distance; that is to say, at two yards' distance the light will only be *one-fourth* of what it was at one yard, or at three yards only *one-ninth*, and so on, the atmosphere being clear. Amongst the various sources of light which have been used for illuminating lighthouses, may be enumerated oil, tar (as in Beale's light), gas, the Drummond or lime light, and electricity. Although we are now able to boast of splendid lights exhibited by many of our lighthouses—a matter in which our neighbours, the French, are in no way behind us—it is a singular fact that for fifty years after the Eddystone lighthouse was completed it was lighted only by *tallow candles*, and so recently as 1801 the lighthouse at Harwich had a *flat plate of brass* placed at the back of a *coal-fire* to guide the mariner on his course.

With reference to the employment of oil, we have already shown how best to utilise its flame—namely, by the employment of an Argand burner and a glass chimney. The apparatus for obtaining light from the combustion of tar is of the following description:—A copper reservoir, similar to that of an Argand lamp, is partly filled with refuse tar from gas-works, a suitable apparatus being attached to prevent an undue amount of tar being admitted. Leading from this reservoir is a pipe which bends vertically upwards and terminates in a hollow burner, up through the centre of which passes a fine jet communicating with a vessel containing atmospheric air under a pressure of $1\frac{1}{2}$ lb. per square inch. As soon as the tar is lighted, a small lambent flame is obtained; but immediately the compressed air is admitted, the flame is changed into a very brilliant light.

The employment of coal-gas in lighthouses involves too many difficulties to render it a practicable means of illuminating them. Could it be utilised, it would doubtless be preferable to oil, both in economy and brilliancy. Equal, or indeed greater difficulties present themselves in the employment of the Drummond light. This exceedingly brilliant light, called after its inventor, was suggested by him for employment on the Trigonometrical Survey of England, in consequence of the difficulty he often experienced in observing the signals between very distant stations. It had already been ascertained by experiment that a piece of lime when heated by the flame of the blow-pipe emitted a very brilliant light, and the higher the temperature to which the lime was heated, the greater its brilliancy. In the *Philosophical Transactions* for 1826 and 1831 are two papers upon the subject. The apparatus for the production of the light consists of a lamp, which admits at the same time through two separate tubes oxygen and hydrogen gases, in the proportion of one of the former to two of the latter by volume. These tubes terminate in a small chamber, and there become mixed. As in their combined state they form a highly explosive mixture, the greatest care is necessary to prevent the flame from the jet from passing back to this chamber; and to secure this end the tube or tubes which convey the *mixed* gases to the point at which they are ignited, is filled with very fine wire gauze, which impedes the passage of the flame. The jets passing from the chamber are two in number, and the flames issuing from them impinge upon the opposite sides of a ball of lime. The intense heat produced by the combustion of the mixed gases raises the ball of lime to an extreme point of brilliancy, and in order to prevent the too rapid wasting of the ball, it is made to revolve about once in a minute. With even this precaution, however, so great is the heat that the ball has a deep groove cut all round it in the space of about forty-five minutes, and it then has to be changed. An ingenious but complicated piece of mechanism is arranged to effect this change at the right moment, the object being to permit no intermittence of the light, which might be mistaken by a passing vessel.

The brilliancy of the *electric* light is well known, and many of our readers may have seen it. It may be regarded as excelling all other artificial lights at present known, even the magnesium. The ordinary source whence this light is obtained is the voltaic battery, and when required for a short period it is probably the most economical. The mode of obtaining the light from the battery is simply to terminate the wires which lead from its

extremities by carbon prepared in a peculiar manner, and shaped like a pencil of ¼ inch square. The circuit of the battery being completed by contact of the points, they may be withdrawn a certain distance apart, and the electric flame will continue to burn through the space of air between. Care must be taken not to withdraw the points too far, otherwise the flame will cease, and contact must be again made before it will re-appear. The *distance* to which the points can be separated without extinguishing the flame is dependent upon the *number of elements in series* in the battery, and the *volume* upon the *size* of the plates. A self-regulating apparatus is usually employed with the electric light, by which the distance is maintained between the points, allowance being made for the combustion of the carbon. We do not consider it necessary to explain the character of this apparatus in detail now.

The employment of electricity derived direct from a battery has its objections. The expense is very considerable when the time is prolonged, owing to the waste and consumption of some of the materials; and the power of the battery is by no means uniform: for these and other reasons attention has been paid to *magnetism* as a source of electricity. To Faraday is due the merit of discovering that magnetism could be made to develop electricity, and the now common medical coil which is sold by surgical instrument makers affords a familiar type of an apparatus for the purpose.

Professor Holmes has designed a very powerful and effective apparatus, by means of which he obtains an exceedingly brilliant and regular light. It has been employed at Dungeness for a considerable period, and more recently at the South Foreland. The advantage of this method of obtaining electricity for lighthouse purposes lies in the *constancy* of the current, so long as the helices revolve with the same speed.

To quote from a paper read by Professor Holmes before the Society of Arts, in December, 1863, he says:—

"The electricity derived from a magnetic machine is induced in coils of wire, by the changing of the magnetic polarity of pieces of soft iron enclosed within the coils or helices; and the quantity or intensity of the induced current depends, first, on the amount of magnetism induced in the soft iron; secondly, on the facility with which the poles of the magnetised soft iron can be reversed; thirdly, on the velocity with which the change of polarity takes place; and, fourthly, on the length and diameter of the wire forming the helices. The amount of magnetism induced in the soft iron depends on the size and force of the steel magnets employed, and on the weight and softness of the iron in the helices; but in practice the weight of the soft iron is limited by the weight of the steel magnets, for if too heavy the steel magnets will be slowly deprived of their magnetism. To facilitate the change of the poles, the soft iron cores of the helices are not solid pieces of iron, but are tubes, single, double, or treble, as it is found by experiment that the same weight of iron, when divided in this manner, loses or takes magnetism in much less time than when in a solid form."

"There is a limit to the velocity to be employed when the maximum of electricity is required, for this reason. The amount of electricity depends on the amount of magnetism taken up, and the soft iron takes time to become saturated with magnetism: hence, if the velocity with which the cores move from the poles of one magnet to those of another be too great, there will not be sufficient time for the cores to become saturated. But since the quantity of electricity increases with the velocity, it is necessary to ascertain this maximum point exactly, either by experiment or calculation. The length and diameter of the wire must vary according to the current required; a short thick wire for the helices represents a battery with plates of large area, but limited in number; whilst a long thin wire will represent a battery having plates of small area, but very numerous. From these facts certain known laws are deduced, founded upon which a magneto-electric machine can be made capable of giving a current of any given amount of electricity."

An important feature in Holmes's machine is the method of converting every alternate current into one and the same direction with the intermediate currents. In order to explain this point, it is necessary briefly to state that the electrical currents induced from magnets are very brief in duration, and that the currents are obtained at each change of polarity in the iron cores within the helices, and moreover that the direction of the successive currents so obtained is alternately reversed. The result of this reverse character in the currents is, that one tends to destroy the other if produced in the same wire, unless by some plan all the currents can be thrown in the same direction in that wire.

Professor Holmes explains his arrangement thus:—"The helices are connected in two, four, or more series; and in doing this, care must be observed that the direction of the coil of every alternate helix is in an opposite direction—that is, if one is wound right-handed, the next is wound left-handed; or what amounts to the same thing, supposing all wound in the same direction, then the two inner ends of the helices of, say, Nos. 1 and 2 must be joined to the two outer ends of the helices of Nos. 2 and 3, and so on through the series; and lastly, the ends of the series are soldered to two insulated discs against which two springs press. . . . One half of the helices are arranged so as to arrive on the poles of the magnet at the same instant that the other half are exactly midway between the poles. Thus there are two distinct currents, and what may be called the 'dead' point—that is, the point when the current inverts in one series—occurs exactly at the time when the other current is at its maximum, so that if now the inverted currents can be again inverted in both of these distinct currents, and the two which now flow in one direction can be united as one compound current, it is evident that the result will be a current nearly as uniform as that from a galvanic battery, with the advantage of equable continuity. This is done by the two commutators, which consist each of two insulated rings of metal, of such a form at the periphery, that two rollers or rubbers change sides from one disc to the other at the same instant that the current is reversed; then, by combining the two commutators, a compound current is obtained which produces *a constant white light.*"

We cannot now enter into a description of the professor's regulator. Suffice it to say that he has succeeded in producing a most intense light, which may be maintained for any length of time, which does not require to be trimmed or extinguished for a second, and which has all the steadiness and uniformity required for lighthouse purposes. The intensity of this light has a power of penetrating haze only equalled by the sun, and its cost, light for light, is far less than the cost of oil.

We regard this invention of sufficient importance, in connection with our subject, to render any apology for having devoted so much of our space to it unnecessary.

It only remains for us now to describe the methods which are employed for utilising all the illuminating rays from the flame—from whatever source it may be derived—for the object intended, namely, that of projecting a ray of light upon a belt of water at a given distance from the lighthouse.

Since the rays of light issue from an illuminated point in *all* directions, it is obvious that a great proportion of these rays are useless and wasted if only required in *one* direction, unless some means can be adopted for bending or *refracting* them in that direction. There are two distinct methods which have been adopted for this purpose, the *Catoptric* and the *Dioptric* systems. There is also what may be termed a third system, in which these two are combined. This is the *Catadioptric*, or, as some call it, the *Holophotal* system.

The Catoptric arrangement is that in which the rays which form the one half of the illuminated sphere are thrown back upon the other half by means of a parabolic reflector. This system was first applied at Dieppe, by Borda, in 1784; although reflectors, probably spherical, had been employed at Marstrand, in Sweden, a short time previously. A first-class catoptric arrangement consists of, say, three sets of Argand burners, three in a set, with a highly polished silvered parabolic reflector behind each burner; the entire system being caused to revolve, by the intervention of clock-work, round a centre, the space between the sets producing the occultation or eclipse necessary, supposing the light is intended to be a revolving one. The reflectors are of sheet copper, plated in the proportion of six ounces of silver to sixteen ounces of copper. They are moulded to the requisite form by beating them with mallets and hammers of various forms, and are frequently and carefully tested. After they are formed to the paraboloidal curve, they are stiffened round the edge by means of a strong bezzle. The form of the reflector is tested by trying a burner in the focus, and measuring the intensity of the light at various points of the reflected conical beam.

The Dioptric arrangement is that in which the rays issuing

from the flame are collected and refracted in a given direction by a lens placed in front of the light. So far back as 1752 a lens was tried at the South Foreland, but abandoned, owing to some mechanical imperfection. In 1819 Fresnel constructed a lens which may be said to have produced a revolution in the method of illuminating lighthouses. Previous to the date mentioned, Condorcet in 1773, and Brewster in 1811, had suggested the idea of *building up* a burning lens in separate pieces. This was the plan which Fresnel devoted himself to perfect in order to apply it to lighthouses, he being at the time secretary to the French Lighthouse Commission, under the presidency of Arago. In a plano-convex lens the rays of light falling upon one of its faces are refracted in lines *nearly* parallel to its axis, but the parallelism becomes less the further the rays lie from that axis, and this aberration is excessive when the lens is very large. It was to obviate this defect, and obtain full command over *all* the rays falling upon the lens, that Fresnel designed his lens. In Fig. 45 we give a diagram of one of Fresnel's lenses in section, showing its action upon the rays it receives. A B is a section of the lens, which it will be seen consists of many separate pieces or rings concentrically surrounding a small central lens L, the whole having their flat surfaces arranged in one plane. S is the source of light, the rays from which falling upon the system of rings, are refracted in parallel lines A A′, L L′, B B′, according to a well-known law. The advantage gained by a Fresnel lens is twofold. In the first place, by combining calculation with experiment, the precise curve of each separate ring is so arranged as to ensure *perfect* parallelism in the refracted rays. Now supposing it practicable to grind a plano-convex lens to such an exact curve as that the refracted rays should be perfectly parallel, we should obtain a lens whose thickness in the centre would be several inches, and the absorption and consequent loss of light by transmission through this mass would be serious. Here then we have the second advantage gained by a Fresnel lens. Looking at it irrespective of the curve, we may regard a Fresnel lens as a plano-convex lens cut into slices parallel to the plane surface, having a disc cut out of the centre of each slice. Our meaning will be better understood by a reference to the diagram (Fig. 46).

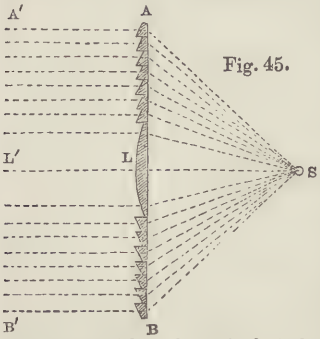


Fig. 45.

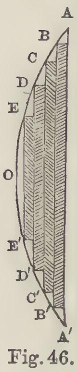


Fig. 46.

Let A A′ represent a section of a plano-convex lens, and imagine it cut into slices by the lines B B′, C C′, D D′, E E′, parallel to the face A A′. Now, since the whole of the refractive action of the entire lens lies in the angle formed by the two lines A A′, A O A′, of which the latter line is curved, it follows that if the various slices be separated from each other, their respective faces being kept parallel, there will be in each slice a central portion bounded by the point at which the curve commences, of which the two faces are parallel, as shown in the diagram by the shaded portions, and to which, in consequence of the parallelism, no refractive action is due. The whole of this portion can therefore be cut away, and the rim remaining—almost precisely similar to a quoit in shape—will exert just as large a refractive action without the central disc as with it, with the advantage of dispensing with a mass of glass whose only effect is to absorb light. If then in each slice the central discs be removed, the several rims remaining can be pushed forward, so that they assume the position shown in Fig. 45.

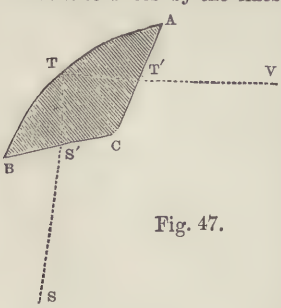


Fig. 47.

In a light of the first order, the central lens is about eleven inches diameter, with a focal length of rather more than 36 inches, and the concentric rings surrounding it (the slices without their discs) gradually decrease in breadth from $2\frac{3}{4}$ to $1\frac{1}{4}$ inches as they increase in diameter. A lens of this description, made of crown glass, will possess a refracting surface of about 1,300 square inches.

A very brief allusion to the *Catadioptric* arrangement is all we can afford space for. This, as its name implies, combines the Dioptric and Catoptric systems in one. The diagram (Fig. 47) will illustrate the arrangement.

Let A B C represent the section of a catadioptric ring, and S the source of light. The ray S S′, falling upon the surface C B of the ring, is refracted at S′ in the direction S′ T; it then becomes completely reflected at T on the curved surface A B, in the direction T T′, and finally emerges in the horizontal line T′ V.

It is easy to perceive that if due care be taken in the grinding and fixing of these rings, they may be so arranged as to *gather up*, so to speak, *all* the luminous rays from S, and throw them into a horizontal direction.

FISH CULTURE.—X.

By Greville Fennell.

OYSTER BREEDING, REARING, AND FEEDING.

Very much of late years has been written upon oysters and their culture, more especially since the great failures around Great Britain and Ireland, and on the Continent, where miles and miles of hitherto prolific parks, both natural and artificial, existed, have become, from various causes, either wholly unprolific, or entirely depleted.

It would be therefore a somewhat profitless work, more particularly where space is of value, to go back for information to books and documents which treat of the past history of these once famed oyster parks as a permanent success. We must therefore take as our guide the latest most reliable authority upon this interesting subject—the Report of the Commission appointed to inquire into the methods of oyster culture in the United Kingdom and France, with a view to the introduction of improved methods of cultivation of oysters into Ireland. The Commission was an unpaid one, composed of J. A. Blake, Esq., M.P., George William Hart, Esq., T. F. Brady, Esq., and Francis Francis, Esq.—the latter gentleman bringing his long practical experience to bear upon the inquiry. The instructions to the Commission are very discouraging upon the subject of oyster culture, more particularly in Ireland, it stating that in that country, out of nearly ninety licences granted by the Board of Works for oyster planting, which embrace an area of about 15,000 acres, scarcely half a dozen can be said to be successful. This is the more surprising, as Ireland is admittingly well calculated for the successful prosecution of *ostreoculture*. The favourable temperature of the sea, the large inlets and bays on the western coast, containing banks where oysters are already found in great numbers, the habits and tastes of the coast population, all show that this most valuable industry might be prosecuted with great success. The Commission was required to visit the principal places in France, England, and Ireland, where oyster cultivation is, or can be, carried on: they were to examine the best authorities upon the subject, and endeavour to ascertain the causes which have led to the many failures which have been experienced.

The young of the oyster, when perfectly formed, attach themselves immediately to the first clean, hard substance they meet with. It has been ascertained that the spat floating in the water for several days is that which from some cause has been ejected before maturity: such spat forms a large proportion of the whole, and during the time in which the spat is free, and is becoming fit for attachment, it is carried by tides and currents to great distances, is devoured by countless enemies, or is driven upon muddy and otherwise unsuitable ground, and so perishes. Under the most favourable circumstances, the proportion that never attaches is very considerable. In a natural state the oyster remains attached, during its lifetime, to whatever object it first adheres to; but after accidental removal it will sometimes again adhere to substances with a hard and tolerably clean surface. To save the bulk of the spat when free is the great object of oyster culture. It may be here stated that the young of all mollusks are apparently free for a longer or shorter term; of this fact the cockle, mussel, winkle, and balanus tribes afford proof.

In the British waters, and those of France, spatting usually takes place when the parent oyster is three to four years old, although it is not uncommon to find oysters milchy at a much earlier period. It has not been clearly ascertained how often during life breeding takes place, but there is no reason to suppose that it does not frequently occur in the lifetime of the same oyster, although it is believed that not more than 10 per cent. of the stock on any bed will usually spat during any one season. As oysters, however, from various causes, have been known to spat very late in the year, it is impossible with accuracy to state the proportion of full-grown oysters that breed annually. The young oyster, when sufficiently matured, rises immediately to the surface upon its emission from the parent, after which it adheres to the first clean hard substances it meets with: this motion is effected by what is termed a swimming pad (Figs. 21, 22, 23), but which is, in truth, but the protruded lobes of the mantle, and not an organ specially formed for locomotion, seeing that by it the shell is secreted. It is by this organ also that the oyster attaches itself, and this, too, in the same way that it forms its shell. Swimming with open shells, and extended mantle uppermost, on meeting with a clean, hard substance, it remains in close contact with it, and secretes over that part of the substance which it touches a coating of the same material of which its shell is formed. The first coating is followed by other layers, and so the once free oyster becomes

Fig. 21. Fig. 23.

Fig. 22.

SWIMMING PAD OF THE YOUNG OYSTER.

fixed, and by a repetition of the process from time to time the necessary increase of shell is made to meet the requirements of the fish. By the same means, also, young or adult oysters, it is said, re-attach themselves to stones or other substances when removed from the places to which they first adhered. That oyster-spat invariably rises when first emitted is a fact to be appreciated in cultivation.

The nature of the bed or soil on which the oyster rests is a matter of the greatest importance, conferring as it does upon the oysters there bred or deposited special flavour or other qualities distinguishing them from all other oysters in adjacent grounds; and this influence prevails to so great an extent that dredgemen can in a fog or dark night readily recognise their position by the shape, size, or colour of the oysters brought up by the dredge; and although the distance between such beds is often small, they are enabled accurately to steer for the harbour from information of this peculiar kind. The nature of the soil is important in another aspect. Many circumstances highly favourable to the growth and fattening of oysters are the reverse for successful breeding.

Growth and fattening will proceed where there may be a large amount of fresh water and a strong current: the former would prove prejudicial to spatting, and the latter tend to prevent the adhesion of spat—at least in the locality at which it is voided.

Good spawning grounds have, on the other hand, been found less suitable for purposes of fattening—pure sea-water, and a clean bottom, essentials for successful spatting, not being always advantageous for the other purposes; hence it is usually found in rivers and estuaries that oysters breed better at the mouth, and fatten best higher up. There are, however, instances where the two processes are found to thrive simultaneously on the same banks.

The present diminution in the supply of oysters appears to have commenced some seventeen or eighteen years ago. Since that period a greatly increased demand for oysters has resulted from the greater facilities of transport to places where previously fresh oysters had seldom reached. Another circumstance has also added considerably to the demand—viz., the more frequent use of oysters, owing to the fashion prevalent both in England and France, among the wealthier classes, of consuming them at almost every meal. This materially enhances the price, and has led to a vast increase in dredging. In 1855 the price of native oysters was 42s. per bushel; and in 1870 it was £8 to £9, while in 1872 it was £10 to £10 10s. A similar rise has taken place in seconds; while commons, in 1855, were 13s. to 14s. per bushel, they were, in 1870, 18s., and in 1872, 20s.

Considerable difference of opinion exists as to the cause of this decrease in oysters, some authorities contending that it is altogether due to over-dredging, others to failure in the natural production of spat. There is no doubt, however, that the principal cause of the scarcity is attributable, both in France and England, to over-dredging; and this we can deal with, and to a certain extent counteract its effects, by wise legislation.

No better illustration, says the Report, can be given than the advantageous position which Ireland occupies when compared with either of the other countries. That her natural beds have suffered much less from exhaustion may be attributed in a great measure to the enforced close time and other salutary regulations made by the Commissioners of Irish Fisheries, which are not in existence in England, and only lately came into operation in France.

The oyster fisheries may be divided as follows:—Firstly. Natural banks, where, without any action on the part of man, oysters are propagated. Secondly. Banks partly natural and partly artificial, as in the rivers of Auray and other places in France, and of Essex and other places in England, where the production is aided by laying down fresh cultch (oyster-shells, tiles, stones, etc., for the oysters to adhere to) and stock, and keeping the beds clear of dirt and vermin. Thirdly. Foreshore cultivation, where the spat from oysters on natural banks is saved or caught on collectors placed for that particular purpose. Fourthly. The method of cultivation in enclosed spaces, such as Lake Fusaro, in Italy; at Hayling, the Isle of Wight, and other places.

The process of collecting oyster spat on stones, etc., has been practised at the Isle of Oléron for upwards of half a century, without attracting much attention—a fact which has not been previously noticed by any of the writers upon oyster culture up to the appearance of the Report of the Commission, it having been erroneously supposed to have originated at the Île de Ré; whereas the park system, which Hyacinthe Bœuf introduced into that island, was but a modification of the system followed at Oléron. Bœuf's discovery is said to have been altogether accidental, arising from the storing oysters within a small stone enclosure, and finding some time afterwards that a large quantity of spat had adhered to the stones. Encouraged by this, Bœuf, in the ensuing year, made a larger enclosure on the foreshore, and laid down more oysters and stones. The result was most successful, and many of his neighbours seeing this, engaged in like enterprises, and were so well remunerated for their trouble and outlay that an extensive cultivation on this plan was soon in operation on various parts of the shores of the island. These layings do not extend beyond low-water mark, and in most places the water is retained by small embankments. The results were much greater the first few years than they have been latterly; indeed, we hear that they have lately been nearly, if not wholly, destroyed by mud and sand. In 1859 the number of oysters was 157,500, valued at £126; in 1863, 5,650,250 oysters, valued at £4,535; and in 1867, 879,713 oysters, valued at £1,245.

The young oysters are usually removed from the stones at one year old. They are then placed in claires to grow and fatten, the time they remain in claires varying according to circumstances in the different localities.

The cause assigned for the recent failures was the improvidence of the concessionaires in selling off all the stock as soon as it was marketable, and leaving none from which to replenish the beds. But to a large extent it is probably also attributable to the stones, tiles, or other collectors being in a cleaner condition during the first year than they were afterwards, sufficient care not being taken to keep them free from mud and weed, without the observance of which precautions the adhesion of spat to collectors is very doubtful.

In our next paper on this interesting subject we shall call attention to some of the principal localities in which oyster-farming has been carried on, and the different modes adopted in this branch of shell-fish culture.

SHIP-BUILDING.—XIX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

BULKHEADS.

HAVING considered the three great subdivisions under which the principal parts of the structures of ships may be arranged —viz., the framing, skin, and decks—it will not be out of place to devote attention to some parts which can scarcely be included under either of these heads, although they are far from being unimportant. Chief amongst these stand "bulkheads," *i.e.*, the transverse or longitudinal partitions fitted in the holds of ships, whose principal features we will proceed to describe.

The bulkheads, or partitions in the holds of ordinary wood ships, are built almost solely with a view to convenience of stowage, their positions being determined quite independently of any considerations of safety, and their construction being very commonly such that they are not water-tight. There have, we believe, been some few cases in which a different plan has been adopted, the bulkheads being made water-tight and placed at comparatively small intervals apart; but this arrangement has only been had recourse to where an exceptional degree of safety was considered desirable—for example, in ships sent to the Arctic regions, and liable to serious injuries from the ice.

The general use of water-tight bulkheads dates no further back with us than the introduction of iron ship-building. Mr. Charles Wye Williams was, we believe, the first to recommend their adoption as a means of gaining increased strength and safety in iron ships; and the practice of fitting them has since become common, although the full advantages possibly derivable therefrom are not commonly obtained. In nearly all cases they are placed transversely, but in some vessels longitudinal partitions are also built. They are usually formed of thin iron plating stiffened by numerous angle-iron or T-iron bars, and thus made more or less rigid, adding greatly to the transverse strength of the ships. Of late years similar bulkheads have been fitted in composite ships, and also in some wood ships, mainly with a view to structural strength, but also as a means of increasing safety. With a wood skin, however, it is difficult to secure the thorough water-tightness at the edges of bulkheads which can be obtained in iron ships; nor is this equally necessary, because thick wood planking is less liable to penetration than thin iron plating, and because a leak in a wood bottom can generally be stopped more easily than one in an iron bottom. Fortunately, therefore, water-tight subdivisions can be made most efficient in the class of ships where they are most required.

Experience has furnished ample evidence of the great advantages gained by a proper arrangement of the bulkheads in iron ships, and of the dangers incurred by neglecting such arrangements. On the one hand, numerous cases are on record where iron ships have been kept afloat and safely navigated into port after receiving serious damage by collisions, grounding, fire, and other causes: on the other hand, many instances might be referred to where iron vessels have been lost for want of efficient water-tight subdivision of the hold. There is no difficulty in ascertaining the reason why ordinary iron ships are left open to the chance of such casualties. The rules which govern the practice of private ship-builders state the minimum number of bulkheads required in different classes of ships, and leave it to the ship-owner and ship-builder to decide whether a larger number of bulkheads shall be fitted. The "classing" of a ship, together with her rate of insurance by the underwriters, not being affected seriously, if at all, by the provision or non-provision of additional water-tight subdivisions, it is not surprising to find that the cheaper but less safe and strong arrangement is commonly preferred. The decision in favour of this course is, moreover, partly due to the consideration that the stowage of cargo in a merchant ship is much facilitated when the hold is free from obstructions or subdivisions. But, while this is true, the fact remains that, as regards safety, the common plan leaves an iron ship with an insufficient number of bulkheads.

Take, for example, a sailing ship built of iron in accordance with Lloyd's Rules. She need only have one bulkhead, fitted moderately near the bow, and known as a "collision" bulkhead, because it provides against injury to the bow in case of collision. No doubt the dangers from this cause are greater, and of more frequent occurrence, than those arising from penetration of the bottom abaft the bulkhead; but supposing a leak to occur in the after portion of the vessel, and to overpower the pumps, her loss would be almost certain. Taking the case of a screw-steamer, built in accordance with the rules, a not much more satisfactory arrangement is met with. Such a vessel would have, in addition to the collision bulkhead, two others enclosing the engine-space, and another placed near the stern. The latter is intended to provide against chance of injuries to the screw-propeller and shafting, such as have caused the loss of some ships; and the engine-room bulkheads are designed to keep that space as free from water as possible in case of injury to the other compartments. These compartments are, however, frequently so large that if one of them be injured and filled, the ship cannot be kept afloat.

More satisfactory arrangements are made in many vessels than are rendered compulsory by the rules, and such arrangements are obviously most requisite in passenger or emigrant ships, wherein large numbers of people are embarked, as well as in war-ships, where the chances of penetration under water by projectiles, by torpedoes, or by ramming, are great. Taking, for instance, one of the iron-built armoured ships of our navy, we find that in addition to a water-tight double bottom, she has eight or nine transverse water-tight bulkheads by which the hold-space is divided into compartments of comparatively moderate size. A slight injury would, as was before explained, only admit water into a small compartment of the double bottom, and not result in its entry into the hold; and this is most important, because it would practically prevent any loss of efficiency in the ship. But in case of a more serious injury occurring, and leading to the penetration of the inner as well as the outer skins, the water-tight bulkheads would confine the water to the damaged compartment, and the ship would remain afloat. Merchant ship-builders, as a rule, do not care to incur the expense of fitting double bottoms, or to lose the hold-space, which would not be occupied by cargo if there were an inner skin, and consequently they have to depend for safety entirely on the bulkheads, the arrangement of which should, therefore, be most carefully considered.

Two principal objects should be kept in view in making such an arrangement. The first, that no single compartment should be left so large as to sink the ship if it were filled; and the second, that in case any compartment were filled the water from it should not find its way into other compartments. The first is so obviously necessary to efficient subdivision that nothing need be said respecting it; but as the second is sometimes overlooked, a few words in illustration may not be out of place. Ships have been built with a sufficient number of bulkheads, but with these bulkheads ended too low down; so that if a compartment had been filled, the consequent increase in the draught of water of the ship would have sunk the tops of the bulkheads below the level of the water outside, and have allowed the water from the damaged compartment to flow over into the adjacent compartments; thus leading to the loss of the ship. In order to prevent this, the simplest plan is to carry the bulkheads up to such a height as will keep them above the water outside, even when the ship has been sunk deeper than her normal draught by the filling of a compartment. And if this is not convenient, the same end can be obtained by fitting a water-tight deck of iron along over the tops of the bulkheads. It should be added that it is usual to end the bulkheads at the height of one of the decks, so that the last-named plan can be readily carried out when required.

Before proceeding to describe the ordinary methods of constructing transverse bulkheads, we desire to refer briefly to the longitudinal bulkheads sometimes fitted in iron ships. These are generally subordinate to the transverse bulkheads, and are primarily constructed as partitions in the hold to shut off the spaces required for stowing particular parts of the equipment, such as coals, chain cables, powder, shell, etc. etc.; or to enclose water-tight passages, such as the shaft-passages of steam-ships, and the passages between the engine and boiler spaces when they are separated. Such longitudinal partitions may, by care on the part of the ship-builder, be turned into valuable longitudinal strengthenings, and also be made to form further water-tight subdivisions in the hold. Probably the best examples of such care may be found in the armoured ships of the Royal Navy, wherein every longitudinal partition of any importance

is, by a small expenditure of material in the form of stiffeners, turned into a girder; and every space of any size enclosed for special purposes is a subordinate water-tight compartment.

There have, however, been cases in which longitudinal bulkheads have been used primarily as strengthenings of a ship's structure, and raised from their subordinate position into prominence. The *Great Eastern* furnishes the most striking example of this arrangement. For about half the length of this vessel two strong bulkheads are built, reaching from the inner bottom to the cellular upper deck. These bulkheads form the side boundaries of the engine and boiler spaces, and do not interfere with the stowage of the hold. Being strongly built, and well stiffened, in addition to receiving valuable support from the intermediate decks, these bulkheads form most efficient girders; and not only lend their own strength to the structure, but also help the sides in connecting the cellular upper deck, forming the top flange of the girder, with the cellular double bottom, forming the lower flange. In fact, we find in this arrangement another illustration of that admirable combination of strength with simplicity which distinguishes every principal feature in the structure of this remarkable vessel.

There have been many proposals to construct similar longitudinal bulkheads in ordinary iron vessels; but the plan which answers so well in the *Great Eastern* is open to grave objections when applied in smaller ships, where it would interfere with the internal arrangements, particularly in steam-ships. For instance, it would not be easy, in a ship of moderate breadth, to secure sufficient space, between such longitudinal bulkheads, for the engines and boilers; and the stowage of cargo in the hold would be made difficult. To remove these objections, it has been proposed in such cases to have one instead of two bulkheads, placing it along the middle line of the keel; but this plan also has serious disadvantages. In short, as sufficient strength can in ordinary vessels be secured by other means, and the ship-builder left with greater freedom in making the interior arrangements, the use of these longitudinal bulkheads has not found favour, nor is it likely to do so unless the size of ships should be much increased.

Reverting to the consideration of the transverse bulkheads usually fitted in iron ships, we will endeavour to describe briefly the principal methods of constructing them, and afterwards notice some of the plans for securing them to the skin-plating.

The plating of bulkheads is usually worked in horizontal strakes, with the butts shifted either on the brick fashion (illustrated by Fig. 35, Vol. III., page 305), or on the diagonal plan (Fig. 36). In a few instances, however, the plates have been worked with their greatest lengths vertical. The edge-joints, as well as the butts, are generally lapped and single-riveted, and are caulked on the plan followed for outside plating (see Fig. 40, page 351). At the places where the laps and butts cross each other the corners of the butted plates have to be hammered out to a thin edge, so that they may form but one thickness under the edge-lap of the plates above and beneath them. Some builders have preferred to work bulkhead plating flush at the edges and butts; but this is a more expensive plan, and is not commonly used, although it has some advantages as regards strength.

Considering the thin plating of a bulkhead as in place, and subjected to the strains resulting from the motion of a ship at sea, it will be obvious that it would be liable to buckle in various directions, and might cease to be water-tight. In order to prevent such buckling, and to render the bulkhead efficient in assisting to maintain the transverse form of the ship, the plating must be stiffened. This is usually done by means of angle-irons riveted to the plating, and either placed vertically or else arranged in two sets, one being horizontal and the other vertical. The latter arrangement is to be preferred, as it makes the two sets of stiffening bars cross at right angles, and by uniting them to the plating, enables it to resist most efficiently changes of transverse form. When vertical stiffeners only are used, the attachments of the bulkhead to the decks and platforms constitute its sole horizontal stiffening, and this may not always be sufficient. When bulkheads enclose comparatively long spaces, such as engine-rooms, or boiler-rooms, or cargo-holds, where the transverse strength of the decks is considerably reduced by the large hatchways required, it is especially necessary to secure rigidity in the bulkheads; and this is sometimes done by increasing the thickness of the plating; but it is preferable to have recourse to stronger stiffeners. As an example of one of these special arrangements, we may refer to the bulkheads fitted amidships in the armoured ships of the navy. The plating is worked flush, at both the edges and butts, the latter being secured by plate-straps single-riveted. The horizontal joints of the plating are covered by T-iron stiffeners, stretching from side to side; and on the opposite surface of the plating vertical iron stiffeners are fitted at intervals of about four feet. Proposals have been made to use T-iron stiffeners vertically as well as horizontally, but we are not aware that the plan has been applied in practice.

Respecting the construction of the various subordinate longitudinal and transverse bulkheads in the hold, it is only necessary to say that the plating is usually arranged similar to that of the main transverse bulkheads, and stiffened by vertical bars of angle or T-iron.

The modes of securing transverse water-tight bulkheads to the skin-plating of iron ships next claim attention. One of the earliest and simplest connections is that where a single angle-iron is riveted to the edge of the bulkhead, and to the skin-plating; and another, still largely used, differs only in having two connecting angle-irons instead of one. Both these plans, however, are considered by many ship-builders to lead to too great a localisation of the connection between the skin and the bulkhead, and it is urged that means ought always to be provided for distributing the strength of the bulkheads over parts of the skin not immediately in wake of them. These objects are realised better by the connection illustrated in Fig. 57, which is much used in merchant ships. A single angle-iron forms the main connection between the bulkhead and the skin; but additional strength of attachment is obtained by means of the horizontal "bracket-plates" (a, b), which also distribute the support of the bulkhead over two frame-spaces. These brackets are placed alternately on the fore and after sides of the bulkheads, and are near the middle of the strakes of the outside plating. They are very simply formed of plates and angle-irons, and are of considerable service in ordinary iron ships with transverse framing.

This sketch also enables us to refer to the practice of fitting broad liners to the outer strakes of the skin-plating in wake of transverse water-tight bulkheads. In the plan in Fig. 57, it will be seen that the liner stretches from the frame before the bulkhead to that abaft it, and this is the common practice in merchant ships; narrower liners are sometimes used, and may be made to answer the same purpose. These broad liners are fitted because the rivets in the angle-iron connecting the bulkhead with the skin have to be spaced very closely in order to secure water-tightness, their pitch not exceeding five or six diameters. Consequently, the plating is much more weakened in wake of the bulkheads than it is in wake of the transverse frames where the pitch of the rivets is greater; and in order to do away with this inequality of strength, the liners in wake of the bulkhead are broadened so that they may act as *butt-straps* to the specially weakened lines on the plates. The plan is simple, but thoroughly efficient, and its use prevents a recurrence of disasters similar to those which occurred with some of the earlier iron vessels, where, in their anxiety to make the bulkheads water-tight, the builders so weakened the skin-plating that the vessels broke down the sides when severely strained at sea.

In addition to these common methods of securing water-tight bulkheads reference might be made to other plans; but as most of these have rarely, if ever, been employed, we must pass them by unnoticed. Respecting the bulkhead connections in ships built on Mr. Scott Russell's longitudinal system, it will suffice to say that when there is no double bottom the edge of the bulkhead is secured to a belt of plating worked inside the longitudinal frames for the purpose; and when there is a double bottom, the edge of the bulkhead is directly connected with the inner skin. The latter mode of attachment is also employed in the armoured ships of the navy built with double bottoms. In both cases it will be remarked that the longitudinal frames act as most efficient distributors of the strength of the bulkheads over the intervening spaces, and render the use of bracket-plates, such as a, b, in Fig. 57, quite unnecessary. Mr. Russell relies, in fact, principally on the bulkheads for supplying transverse strength to his ships, and experience shows that under ordinary circumstances his expectations are realised, and the

forms of the ships are maintained. He uses also "partial bulkheads," as before described, in order to further strengthen the structure; but does not make his transverse framing so prominent as that of the iron-clads built on the bracket-plate system. The latter system, however, has been shown to possess considerable advantages as compared with Mr. Russell's system, especially as regards the efficient support of the bottom plating; and while in the iron-clads the bulkheads are made to supply the greater portion of the transverse strength, they are not left so unaided as in ships built on the longitudinal system.

When fitted in wood ships, transverse iron bulkheads are secured to the inside of the timbers and ceiling by single or double angle-irons riveted to the bulkheads, and bolted through the ship's side; but in composite ships similar bulkheads would simply be riveted to one of the frame angle-irons. In neither case, however, can the water-tightness of the bulkheads be ensured so thoroughly as is possible in an iron ship.

Longitudinal strengthenings, such as keelsons, hold-stringers, etc., ought not to be stopped short at bulkheads, but either continued through them, or otherwise arranged so as to form continuous ties. Supposing them to be run through the bulkheads, which is the simpler plan, it then becomes necessary to make them water-tight. This can be done readily by fitting forged angle-irons closely around the keelson or stringer, and against the bulkhead. After riveting these angle-irons it is possible to caulk all the joints, either on the lap or flush system.

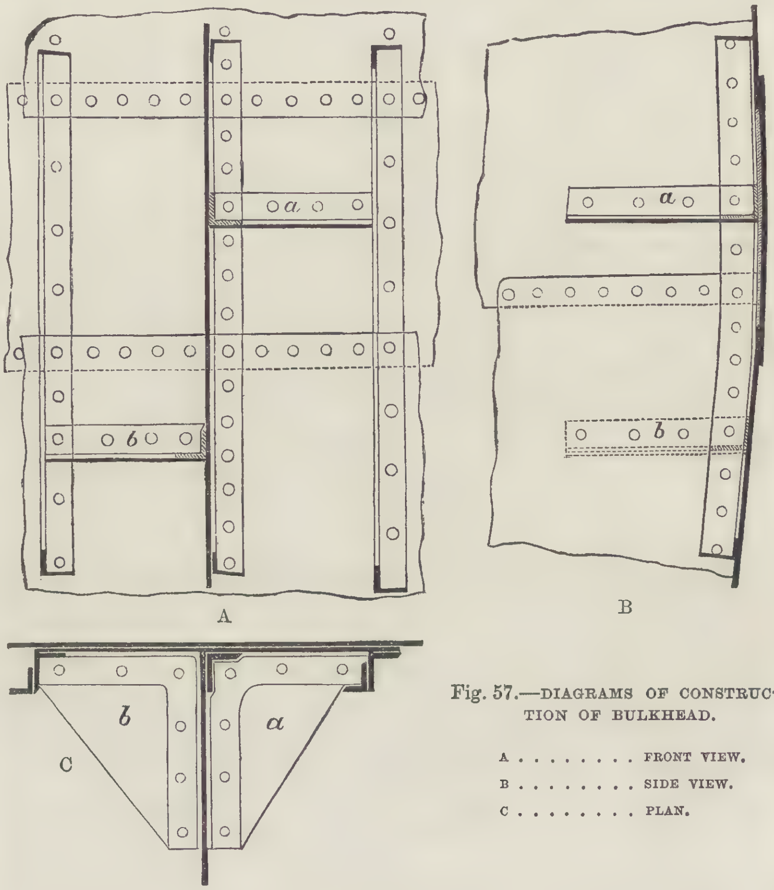


Fig. 57.—DIAGRAMS OF CONSTRUCTION OF BULKHEAD.

A . . . . FRONT VIEW.
B . . . . SIDE VIEW.
C . . . . PLAN.

Care must also be taken to test the water-tightness of the bulkheads after the work is completed, if efficiency is to be ensured. One mode of testing is to fill the compartments with water, in order to detect any leaks that may exist; but this involves much labour and expense when the compartments are large, and a more common plan is to pump water upon the bulkhead (by means of a fire-engine and hose) with considerable velocity. In testing the compartments of the double bottom in the iron-clad ships of the navy, it is usual not only to fill the compartments, but also to put the water in them into communication with a stand-pipe, also filled with water, and leading up to the height of the loadwater-line. By this arrangement it is ensured that there shall be no leak under the maximum pressure to which the boundaries of their respective compartments are subjected when the ship is afloat.

For the purpose of facilitating communication between the different parts of the hold, openings are frequently made in the water-tight bulkheads, and water-tight doors are required. These doors are usually formed of cast or wrought iron plates, and are made to slide either vertically or horizontally in grooved framework fixed on the bulkhead plating. The edges of the door are commonly wedge-shaped, and so also are those portions of the grooves in which the door rests when it is shut; so that a close fit of the bearing surfaces of the door and framework is ensured, and water-tightness is secured. In order to give the necessary sliding motion to these doors, vertical shafts or rods are generally fitted, being made to extend up to one of the decks, where they can be turned by means of a spanner or other device worked by hand. If the doors slide horizontally, their motion is generally caused by pinions on the shafts gearing with racks fixed on the door. If the doors move vertically, there are usually screw-threads cut on the lower ends of the shafts, and these work in nuts secured to the doors. All these arrangements, however, are open to endless modifications; but what is really important in all of them is to give the crew of a ship the power of closing the water-tight doors from the deck above, even after the rush of water into a damaged compartment has begun; and to enable them to ascertain, without actually going down into the compartment, whether the doors are closed or not. Similar precautions are necessary in fitting "sluice-valves" to water-tight bulkheads. These valves are usually opened or shut by means of rods leading up to one of the decks, and are intended to allow the bilge-water to flow from one compartment into another when the pumps are at work.

In the iron-clads of our navy the bulkheads extend up to the main deck, and it is very important that ready means of passage fore and aft should be provided on the lower deck. For this purpose light hinged doors, formed of plate-iron, stiffened on the edges, have been fitted to the bulkheads. When closed, these doors fit closely into a rabbeted frame fixed to the bulkhead plating, and are pressed tightly (by means of wedged catches) against a "beading" of india-rubber fitted in the rabbet for the purpose of making the joint water-tight. This plan is simpler and much less costly than that followed for the water-tight doors in the hold, and it answers perfectly in the places where it is used, because, being at such a small depth below water, there is every probability, in case of an in-rush of water, of sufficient time being obtained to close these doors and secure them by hand before the water rose high in the compartment. In the hold, as we have already remarked, the case would probably be different, and the doors must therefore be so fitted as to be closed by some simple train of mechanism worked from above; besides which they must be made capable of sustaining a considerable pressure of water without leaking. It need hardly be added that the water-tightness of all such doors, wherever placed, should be carefully tested; and this is usually done when the bulkheads themselves are tried.

MINING AND QUARRYING.—XXVIII.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

RED LEAD OR MINIUM—CHLORIDE OF LEAD—WHITE LEAD OR CERUSE—DUTCH PROCESS—THENARD'S PROCESS—LEAD-POISONING.

In addition to the oxides of lead described in the last article, there is another of very extensive use in the arts, and the manufacture of which forms a special trade. It is commonly known as red lead or minium. The very finest metal is used for the purpose, especially if the red lead is intended for sale to the flint-glass makers, as the presence of other metals will prevent the glass from being so clear and lustrous as it would otherwise be.

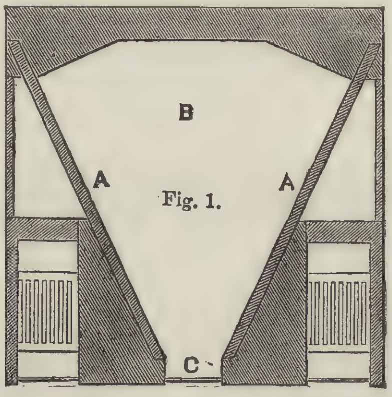


Fig. 1.

The first step in the manufacture is to convert the lead into the familiar protoxide, which is more usually called "dross" by the workmen than litharge or massicot. The drossing-oven is on the reverberatory principle, but it is generally made with a fire on both sides of the hearth, as shown in the diagram (Fig. 1), and without a chimney, the waste gases escaping from the top of the working-door. The heat required does not exceed dull redness, and some ovens are even made without fire-bars, there being sufficient draught from the charging-doors to keep lumps of free burning coal alight. The flames from the fires pass over the fire-bridges, A A, and circulate over the hearth B, which is about flat, and is so shaped that the whole area of it can be rabbled from the working-door, C. Just inside the latter a dam is made to prevent the lead when it melts from running out, and then the charge, consisting usually of something over a ton of lead, is introduced. If the minium is not intended for the glass manufacturers, about 1 cwt. of slag lead is added, the antimony which the latter contains having the effect of greatly expediting the oxidation of the whole mass. As soon as the lead has melted, rabbling is commenced and kept up vigorously, so as to expose the lead as much as possible to the action of the air; and as the oxide forms it is pushed up in a heap at the back of the oven. This process is continued for several hours, and then the dam is removed, and whatever lead remains unconverted is run out and put aside to be added to the next charge. The "dross" is then raked out from the back of the furnace and left to cool. It is next taken to the grinding-mill, where it is ground under millstones to an impalpable powder, or rather made into a fine paste as it is ground with water. From the mill it flows into the puddler, where it is agitated in water, and the finer powder is afterwards separated from the coarser in settling tanks. From these it is taken (after being dried) to the colouring-oven, which, in some works, is the same as the drossing-oven above described, and it remains there exposed to a moderate heat, varying from 550° to 600° Fahrenheit for about forty-eight hours. During this time it is frequently rabbled, and by the period named it will have acquired the full red tint characteristic of red lead. It is finally re-ground and sifted, when it is ready to be packed in casks for the market. The product should show an actual gain in weight of 7 or 8 per cent., due to the absorption of oxygen.

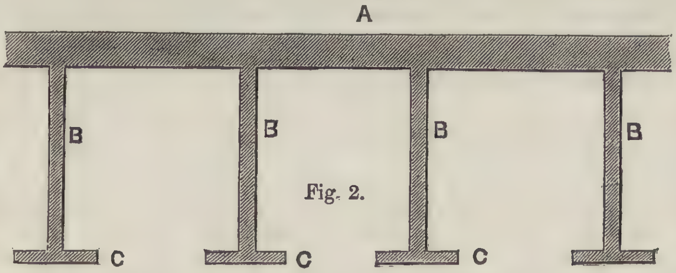


Fig. 2.

Minium is used for very similar purposes to litharge; but as a pigment it furnishes a much superior colour: ground in oil it forms a paint which possesses in a high degree the faculty of drying rapidly in the air. In the glass and pottery manufacture one of its chief values consists in the readiness with which it combines with silica and alumina, forming with them a vitreous compound or glaze. The acetate of lead has been already described in the series on "Chemistry applied to the Arts," No. XV.

The chloride of lead is a salt which has only recently been manufactured on a large scale. It is used by painters, and has the advantage over the carbonate of lead, which is generally used, in not being blackened by the sulphide of hydrogen, which so often causes the discolouration of white paint, especially in large towns.

The carbonate, generally called white lead, flake white, or ceruse, is, however, the almost universal foundation for all lead paints, and is therefore an article of very extensive manufacture both in this country and on the Continent. Some of the German makers used to be very celebrated for the superior quality they produced; but now our own manufacturers leave nothing to be desired in this respect.

The usual plan, commonly called the Dutch, consists in exposing lead for a prolonged period to the gentle action of the vapour of acetic acid and carbonic acid gas. The effect of this is to produce an acetate of lead, which is converted in its turn into a carbonate. The mode by which this chemical change is brought about is somewhat peculiar. The factory consists of a large building having the sides, one of which is represented by A (Fig. 2), divided by brickwork partitions, B, B, into a series of recesses or chambers, which are partially open towards the centre of the premises. The dimensions of these chambers are about fifteen feet each way for the area, and the height from the floor to the roof about twenty feet. As a matter of convenience, the floor of the recesses is generally sunk some feet below the rest of the building. These are the receptacles for the stacks, which are built up in the following manner:—The sides are lined all round with spent tan for about sixteen inches, and a layer to about a similar depth is spread over the bottom; upon this a quantity of earthenware pots, containing a little acetic acid or vinegar, are set in regular rows as close as they can stand, and on the top of the pots slabs of lead are laid; a floor is then made of planks, and upon this another layer of tan, pots, and lead; and so on until the stack is complete. A stack will thus contain a series of eight to ten beds, one above another.

In Fig. 3, B will represent one of the partitions, and D the floor of the recess; E E, etc., the tan; F F, the pots; and G, the lead slabs. Of these, however, a few more details must be given. In some manufactories stable dung is used instead of tan; the functions performed by either the one or the other are the same—that of creating a considerable warmth which assists the evaporation of the acetic acid, and of evolving the carbonic acid which is necessary to convert the acetate into the carbonate. The use of dung is, however, objectionable, because it also evolves some sulphuretted hydrogen, which is liable to destroy the perfect whiteness of the product. The pots, it will be observed, are of two sizes and shapes: the larger ones taper very much to the bottom, while the smaller do so very slightly, if at all. In some works they are just the shape of common jam pots. The larger pots are about eight inches high, and made with a ledge running round the interior; the part below the ledge is filled with weak acetic acid, and a spiral coil of lead is placed in the upper part, and rests upon the ledge, so as not to touch the acid. In each of the smaller pots a little acid only is poured; except here and there, where one or two of them are nearly filled with common vinegar. Upon the top of the smaller pots are laid the slabs of lead. The metal for this purpose is melted in an iron pot at a low temperature, from

which it is ladled out and poured upon an iron slab grooved with longitudinal and transverse gutters an inch apart, into which the lead runs: it thus forms a perforated slab resembling a grating or trellis-work. For the coils put into the larger pots, the lead is cast into long narrow strips, which are afterwards rolled up into coils. The slabs of lead are made in the form selected in order to allow of a free circulation of air around them, and also to admit of their expansion, as during the process they swell up to about three times the size of the original metal; additional space for this purpose is allowed between them and the planking, H H, which rests upon the rim of the larger pots and supports the next bed. The uppermost bed of all is covered with the tan or dung to the depth of about two feet; and as the beds are built up above the floor of the workshop, the open side, C (Fig. 2), is filled in with planking. In this condition the stack is left for six to ten weeks. If stable litter is used, the former time will be long enough, as it heats more than tan—sometimes, indeed, too much, as the acid then evaporates too rapidly, and the produce is not so satisfactory. Each stack will contain ten or twelve tons of metal. By building up each stack in succession the work of the establishment can be kept going uninterruptedly, as the first one will be ready to be dismantled as soon as the last is completed.

In taking down the stack the top covering is removed, and then the slabs and coils of lead are carefully lifted off and put into boxes to be carried away to the unscaling apparatus. The lead, partly corroded, is thickly covered with the carbonate, a flaky white substance, consisting of particles so finely divided that unless handled with care some of it is apt to get into the air, when it would exercise a very injurious effect upon the health of the workmen. They even wear leather gloves in some factories, so as to avoid touching it with their hands. The removal of the carbonate from the metallic core is done by passing the pieces under grooved rollers, and agitating them under water, and the metal is returned to the melting-house. The carbonate, while still wet, is passed under a series of millstones, from which it issues in a pasty state, and is conducted into the settling vats. When the water has separated and become perfectly clear it is drawn off, and the carbonate is put into flat dishes and ranged on shelves in the drying-room. This is heated by a close iron stove in the centre, which is supplied with fuel from the outside, and here the carbonate of lead is thoroughly dried in the course of a few days. It then only remains to knead it up with oil, and pack it in casks.

It is seldom, however, that the white lead made for painters' use is pure. There are mixtures well recognised in the trade, which bear specific names. Venetian white consists of equal parts of carbonate of lead and sulphate of baryta; Hamburg white, one-third of the former and two-thirds of the latter; and Dutch white, one-fourth and three-fourths respectively.

There are other modes of preparing white lead, most of which are modifications of the principle first carried out successfully at Clichy in France, whence the article produced by this process is often called "Clichy white." Thenard's system, which is the basis of all these, consists in preparing a solution of basic acetate of lead, and then passing carbonic acid gas through it, producing the carbonate of lead and a neutral acetate. The apparatus used at Clichy consisted of a large vat furnished with a rotatory stirrer for dissolving litharge in acetic acid, and when the acetate of lead had attained a proper strength it was drawn off into another vat to settle. The clear liquor was then drawn off again from this into the converting vessel, a long shallow tank, over which depended a series of twenty horizontal pipes connected with a main, and from each of these forty smaller pipes extended perpendicularly to a depth of thirteen inches below the surface of the acetate of lead. The main was connected with a pump, which was supplied with carbonic acid from the kiln in which it was made. When at work, therefore, 800 jets of carbonic acid gas were injected into the lead solution, and the carbonate thus formed was thrown down to the bottom of the converter as a fine white powder. The neutral acetate left in the converter was then drawn off into the first vat to dissolve up more litharge, and the carbonate of lead transferred to a vat to be washed, after which it is ready for drying and packing.

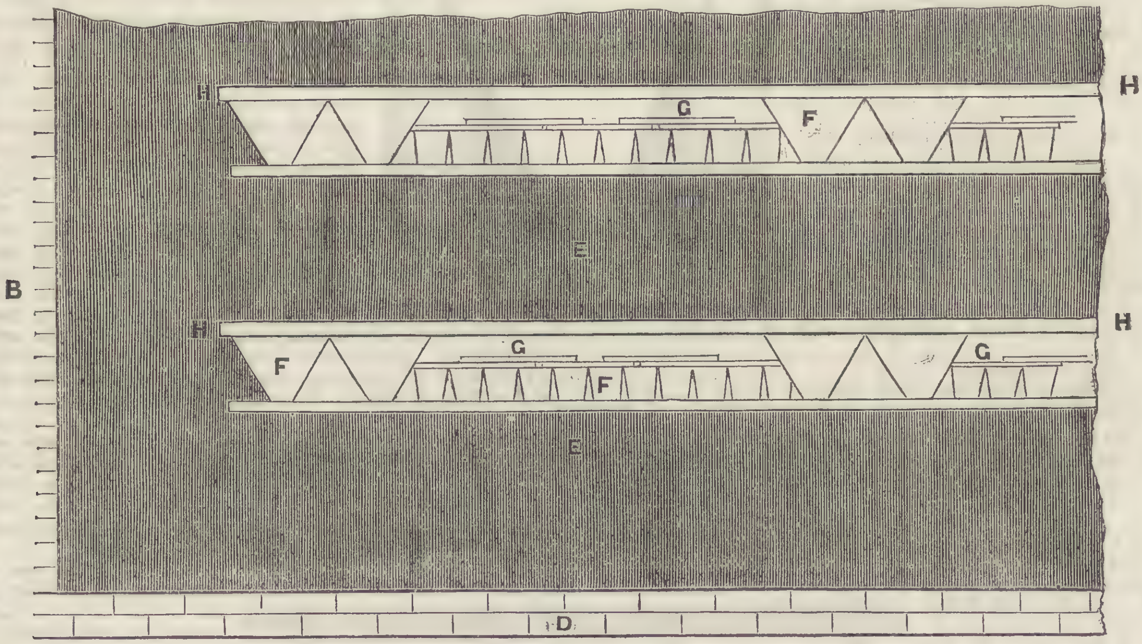


Fig. 3.

In the course of this and the preceding papers on lead the deleterious character of its salts has been referred to several times, and painters' or lead colic is unfortunately but too well known. Indeed, with the exception of the sulphides, sulphates, and phosphates, which are very insoluble, the whole series of lead salts may be considered more or less poisonous. Except in certain manufactures, and especially where the carbonate is dealt with in the dry state, such precautions are generally taken as to prevent active lead-poisoning; but the cases are not rare where the slow action is continued through long periods of time, producing at length distressing symptoms. This often arises from the water used for drinking or cooking being conveyed through leaden pipes, and held in cisterns lined with lead. Spring water may generally be brought in contact with lead without any bad effect, as the mineral matters contained in it

will most probably form an insoluble compound with the oxide of lead; but rain-water, or any surface-water which contains nitrogen, or any organic matter which will evolve nitrogen, exercises a most pernicious effect, as this element acts immediately on the lead. Fortunately, the presence of even the smallest trace of lead in water may easily be detected. It may be done by putting in the water two or three drops of acetic acid, and then adding about one-twentieth of its bulk of an aqueous solution of sulphuretted hydrogen. On looking down through a tube containing a column of water so prepared, 10 inches in length, upon a white surface, and comparing it with a similar tube containing the water without addition, a brown discolouration, more or less intense, will be seen in the one containing the sulphuretted hydrogen, if lead be present. By taking a standard solution of lead of known strength, the quantity of lead in water may be ascertained very correctly by comparing the depth of colour. The deleterious action of nitrogenous substances in water held in leaden cisterns may be prevented by the insertion of some coils of iron wire, for which the nitric acid has great affinity; but the safest plan of all is to substitute pipes and tanks of some other material.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XIII.—LECTURES AND DEMONSTRATIONS.

Lectures and Demonstrations.—It would at first sight appear obvious that lectures should be given on the collections of the several departments of a national museum, to ensure the public deriving the full advantage of its scientific wealth; but there is great diversity of opinion on the subject, and many eminent men hold a different opinion. Thus Professor Huxley considered that a museum may be regarded as a consulting library of objects, and that lectures on the objects are not more necessary than on the books in a public library.* Others considered that teaching should be accessory only, and chiefly for demonstrating the character of any newly-acquired remarkable specimens. At the Jardin des Plantes, the lectures have not been appreciated as fully as might have been expected, and their ablest lecturers have found that after their first and second lecture, their auditors have diminished to six or seven constant attendants, *but then those six or seven afterwards became men of repute!* In our own country we have met with similar experience. Thus, at Oxford, Professor John Phillips gives an annual free course on some subject of geological interest: a few years since it came to my knowledge that he had prepared a most interesting series of demonstrations on fossil echinodermata, but after the first lecture he had only *one* regular attendant—a well-known palæontologist; but Professor Phillips went manfully through the entire course to the satisfaction of himself and his solitary auditor, as he dropped university formalities, and both went into the subject *con amore, tête-à-tête.*

Cuvier and Geoffroy complained of the injury often inflicted on choice specimens by their removal to the lecture-theatre; and further, that the utilisation of the Museum specimens for lecture purposes, entailed loss of the curator's time in having to derange and re-arrange the cases. Such objections may be obviated by giving demonstrations in the galleries in place of lectures in a theatre, which would not entail the removal of the specimens; but Dr. J. E. Gray is of opinion, from what he has seen at the British Museum and College of Surgeons, that from the crowding of the auditors on the demonstrator, and the manner in which the specimens are obstructed from the view of a great number of persons, such a system does not give promise of a successful method of imparting instruction, but that catalogues are the most convenient guides for the general public. From the evidence we have before us in the "Report of Committee on Public Institutions" as to the manner in which the public lectures at the School of Mines have been appreciated by the working and middle† classes, and the wide-spread increasing taste for scientific knowledge, especially in the department of Natural History, the success of the Quekett Club and similar microscopic and natural history associations in London and the provinces to wit, together with the commencement in earnest of science-teaching in our public schools, affords justification for believing Professor Owen's inclusion of a lecture-theatre in his plan for a National Museum of Natural History, an act of sound policy, with the view of extending sound information among the people on "the extent and variety of the Creative power." He considers that, during the year, at least nine courses on as many branches of Natural History should be given in connection with the museum; popular evening lectures in the theatre on the Elementary, British, and Geographical* collections; and advanced lectures three times a week on the special departments by their keepers to a limited number of persons who have attained a certain standard of scientific knowledge, but without establishing any restriction as to class. Twelve to twenty lectures to be given by each keeper. Probably it would be better if the advanced lectures were given in the galleries to which each subject pertained in the form of demonstrations, as then the specimens, with exceptional instances, need not be removed from their cases, thus meeting the objections raised on the score of possible damage to the systematic collection, which would include the rarer objects of the Museum. Such demonstrations should be given from four to five o'clock, after the closing of the galleries to the general public. The objectionable crowding on the demonstrator could readily be provided against in a limited class, by portable barriers that could be removed from one spot to another, together with a diagram screen and blackboard. Such demonstrations by those whose duty it would be to be "posted up" in the latest knowledge pertaining to their special department, would be most advantageous and acceptable to working naturalists, and would generally tend to the extension of sound research among British students and naturalists.

The subject of lectures on our national collections raised the question as to whether it should become one of the necessary duties of a keeper or assistant keeper of a department to give a course of lectures. It was argued that the qualities for a good curator and a good lecturer are not always combined in the same person. The qualities calculated to attract an audience are by no means the qualities necessary to constitute a good curator. Patient research, constant attention to detail, care in the compilation of catalogues, taste and skill in arrangement, capacity for administration, are essential for the one; an easy delivery, and power of popular illustration, are chiefly required in the other. A good lecturer might not be a sound naturalist, but his acquired popularity might be brought to bear, and pressure put upon the appointing powers, to secure his election (though not the best man among the candidates) as curator of a department. Such an objection would naturally be raised by those curators who had never taken any position as lecturers; but we have among us men who have attained eminence in both capacities; and on the Continent, especially at the German universities, the professors are, as a rule, the curators of the collections in the University Museums, that illustrate their own subjects. Were the duties of curator and lecturer made distinct, it would deprive some of our most distinguished teachers of the control of the specimens that illustrated their lectures, and moreover might lead to want of harmony between the doctrines as enunciated in the lecture-room, and the arrangement of the collections in the Museum. Moreover, curators would naturally object to be made responsible for the safe keeping of specimens placed at the disposal of lecturers not on the Museum staff. If the demonstrating system were determined on for the systematic series, it would remove many of the difficulties that have been raised to the union of the two offices, as elegance of language, easy flow of words, and facile illustration, are not so essential for the terse and practical descriptions of the demonstrator. The keepers of a National Museum are really the only persons to whom naturalists, etc., could look for *information in detail* on all the great divisions of Nature, or in other departments of knowledge. Thus, at the present moment, the most extensive Government course on *general*

* Report on British Museum Committee.

† Evening lectures at a fee of five shillings a course have been provided for the middle classes, which have always been well attended.

* As the geographical groups would be unsuited for removal to the lecture-theatre, counterpart photographs could be shown on a large scale by means of the demonstrating lantern, and so the public could be familiarised with the detailed history of the groups themselves.

Natural History comprises forty lectures on Mineralogy, *none on Botany*, eighty on Zoology (embracing Comparative Anatomy, supplemented by demonstrations on Palæontology), and thirty-six on Physical and Stratagraphical Geology, which only admits of typical illustration.

TECHNICAL DRAWING.—LXXIX.

DRAWING FOR CABINET-MAKERS.

FIG. 613.—In the present study the bookcase is turned so that the front is at right angles to the plane of the picture, the narrow side (or depth) being parallel with it.

Draw the rectangle A D F′ F, representing the narrow side, and having drawn the horizontal line at the same height as in the previous lesson, set off the point of sight at eight feet (in this case) on the left of the perpendicular A, and the point of distance at eleven feet on the right of the point of sight, both of these points being, as in the last lesson, omitted from the illustration.

From A and D draw lines to the point of sight. From A set off A B, equal to the width of the front of the case, as shown in the last study, and from B draw a line to the point of distance, cutting the line drawn from A to the point of sight in B′.

At B′ erect a perpendicular, meeting the line drawn from D to the point of sight in C, thus completing the representation of the object rendered as a block.

From A set off A *a*, and from B set off B *b*, the real thickness of the wood, and from *a* and *b* draw lines to the point of distance, cutting A B′ in *a′* and *b′*; at these points draw perpendiculars.

Now on the perpendicular A set off A *i*, equal to A *a*, and set off the same length from D, viz., D *d*. From *i* and *d* draw lines to the point of sight, and thus the apparent thickness of the wood forming the carcase will be represented.

We have now to show the interior of the case; and in order to do this, it becomes necessary to render the narrow side A D F′ F transparent. Therefore draw (in dotted lines) the ends of the top and bottom, viz., *i k* and *d l*, and also the perpendicular *k l*, showing the thickness of the back of the case.

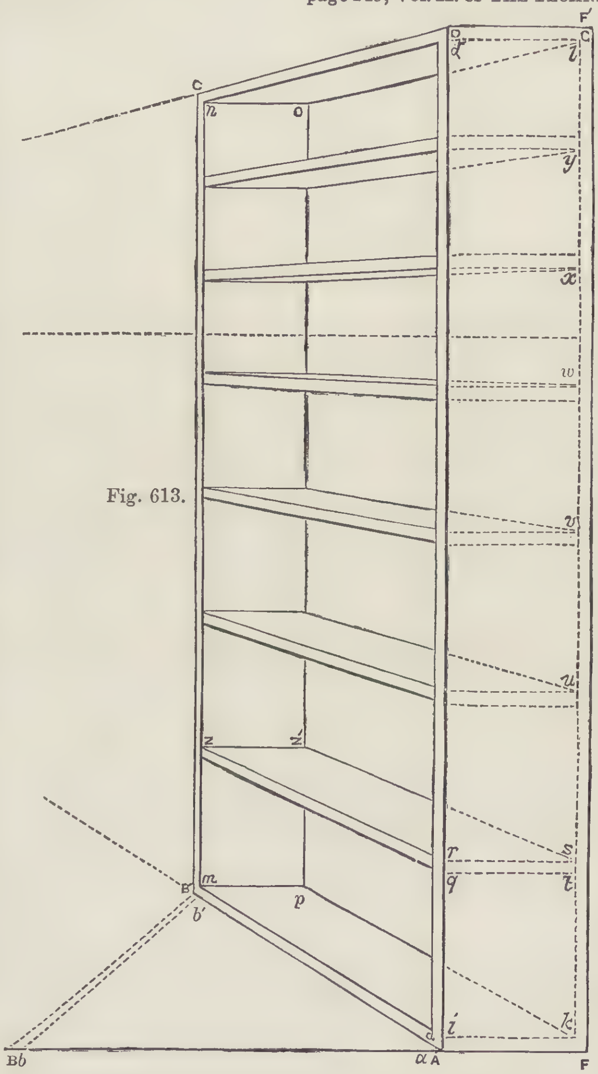


Fig. 613.

Now from *k* and *l* draw lines to the point of sight, and from *m* and *n* draw horizontals, cutting these in *p o*. Then the perpendicular *p o* will complete this portion of the subject.

We now proceed with the shelves. Mark the thickness of these at their proper places on A D, and draw lines from these points to the point of sight, observing, of course, that these lines are not to be drawn across the thickness of the framing, but only between the lines forming the inner edges of the walls.

Now from the points marking the positions of the shelves, as *q*, *r*, draw horizontal lines representing the ends of the shelves as they would appear if brought quite up to the plane A D F′ F. These ends, however, must not be carried as far as the line F F′, but only up to *k l*, which represents the inner line of the boards forming the back of the case, the shelves thus terminating as shown at *s t*.

From *s*, *t*, *u*, *v*, *w*, *x*, *y*, draw lines to the point of sight, cutting the perpendicular *o p*; then horizontal lines drawn from the distant ends of the shelves, as at *z*, meeting the others on the line *p o*, as at *z′*, will complete the view of the case of shelves when placed at right angles to the plane of the picture, and eight feet to the right of the spectator.

The subject of the next lesson (Fig. 614) is another view of the sideboard forming Fig. 51 in lessons on "Practical Perspective," page 149, Vol. II. of THE TECHNICAL EDUCATOR. In the present case the sideboard is turned, so that the end is parallel with the plane of the picture, and thus the horizontal lines of the front, being at right angles to the end, converge to the point of sight.

In commencing this figure, draw the side of the plinth which is on the picture line, *a b c d*, and from *a*, *c*, and *d* draw lines to the point of sight—viz., *a e*, *c f*, and *d g*.

Now on the picture line set off from *a* the length *a h*, representing the real width of the front of the plinth (equal to *a b*, the base of the plinth being square). From *h* set off *h i*, the width of the recess between the pedestals of the sideboard; and from *i* set off *i j* (*j* not shown in the figure), representing the width of the other plinth. These measurements may be taken from the front view (Fig. 51, Vol. II., p. 149). From *h*, *i*, *j* draw lines to the point of distance, cutting *a e* in *h′*, *i′*, and *j′*; and at these points erect the perpendiculars *h′ k*, *i′ l*, and *j′ m*. From *k*, *l*, and *m* draw horizontals to meet *d g*, and complete the distant plinth by the horizontal drawn from *i′*.

Draw diagonals in the upper surfaces of the plinths.

From *d* on *d c* set off *d* B*, equal to the distance at which the pedestal cupboards stand back from the front of the plinths, and from B draw a line to the point of distance. From the point at which the line drawn from B cuts *d g* draw a horizontal line, cutting the diagonal drawn from *c* in *n*. From *n* draw a line to the point of sight, which will cut the diagonal drawn from *k* in *o*, and being produced will give similar points in the distant plinth. At these points erect perpendiculars—of indefinite height, for the present.

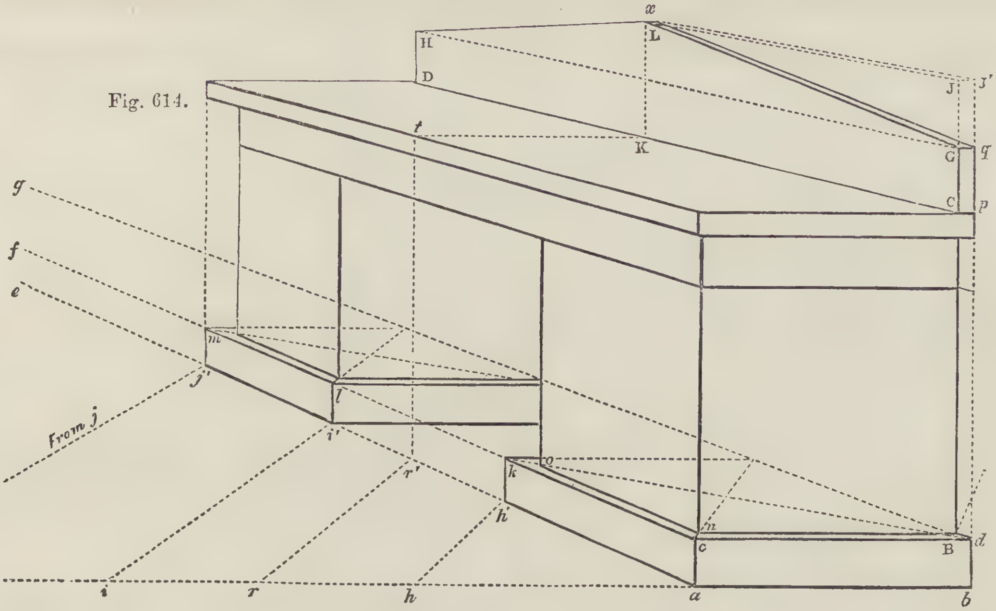
Now draw the slab of the sideboard at the height corresponding with that in the previous figure, its angles being formed by perpendiculars raised from those of the plinths, with which, as already stated, they correspond.

Draw the rectangle C G *q p*, representing the end of the back, and produce it to J, J′ indicating the section of the back at its highest point.

From C and G draw lines to the point of sight, and at D draw the perpendicular D H.

* The points indicated by small capital letters, correspond with those similarly marked in Fig. 51 (Vol. II., page 149).

Fig. 614.



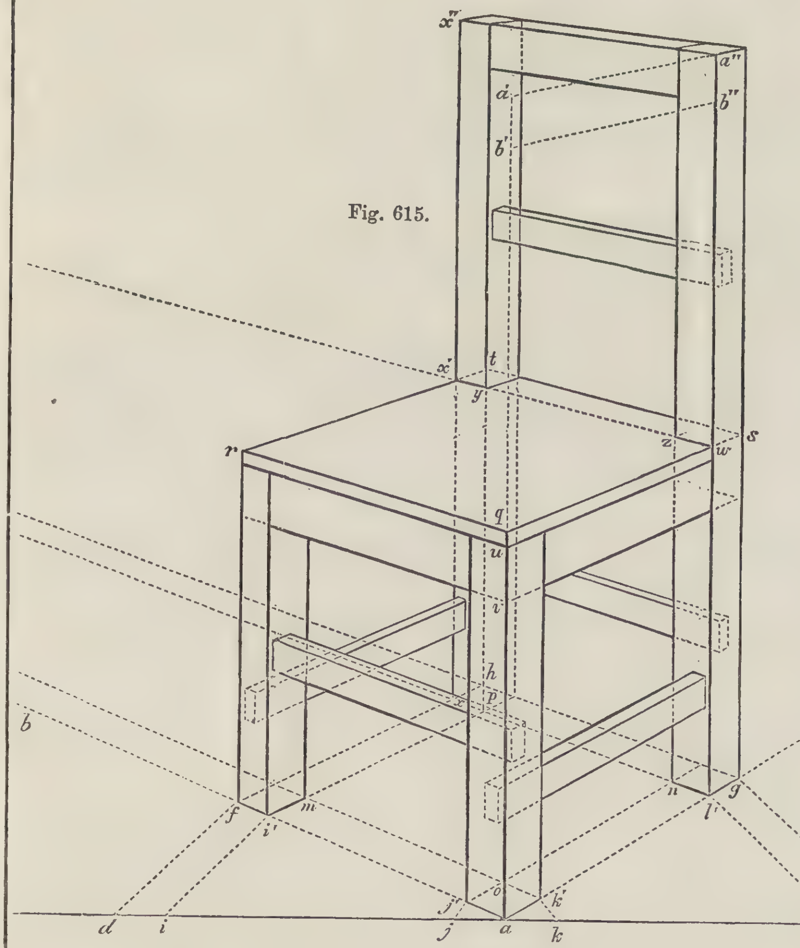


Fig. 615.

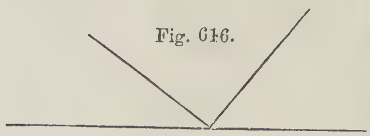


Fig. 616.

Half-way between h and i on the picture line mark r, and from r draw a line to the point of distance, cutting a-e in r'. At r' erect a perpendicular, cutting the upper edge of the front of the sideboard in t. At t draw a horizontal, cutting C D in K, and at K erect a perpendicular.

From J draw a line to the point of sight, cutting the perpendicular K in L, which will be the perspective position of the highest point of the back. Draw G L and H L. From J′ draw a line to the point of sight, cutting a horizontal drawn from L in x, which will give the point of the back behind L. Join this point x to q, which will complete the thickness of the slanting edge of the back. It is to be hoped that any further detail will be understood from the illustration.

On reviewing the subjects of the lessons in "Practical Perspective" hitherto given, it will be perceived that all have been rectangular, and so placed that their front and back have been parallel to the picture plane, whilst the other two sides have been at right angles to it. The horizontal lines of the surfaces parallel to the picture have thus been rendered horizontally, whilst the horizontal lines bounding the sides have been drawn to the point of sight.

The whole system of angular perspective, together with that of the perspective of polygons, is, however, fully given in the course already referred to in THE TECHNICAL EDUCATOR, and to these lessons the student is referred.

Fig. 615.—The subject here represented is a common kitchen chair, simplified in form as much as possible, in order that the leading principles of drawing may be rendered clear. Thus the general plan of the chair is here given as square, whilst in a real chair it would be rather narrower towards the back, and the top rail is rendered as thick as the uprights. The student will soon, however, be able to vary these proportions when he thoroughly comprehends the method of working as shown in this example.

The spectator is supposed to be standing a little on the left of the object, the level of his eye being thus above that of the chair, which is placed at the angles shown in Fig. 616.

The scale, height of spectator, distance, and all measurements, are left to the student to fix. He will thus be prevented from copying the diagram, and will be encouraged to work out his ideas, guided only by the general form shown in the example, and by the principles elucidated in the description.

The picture line, horizontal line, and the line of direction having therefore been drawn, and the vanishing points and measuring points having been found according to the angle at which the plan may be placed, commence the object at a (or any other point which may be determined upon as the position of the angle on the picture line), and from a draw a line to the vanishing points, viz., $a\ b$ and $a\ c$.

Set off on the picture line on each side of a, the length $a\ d$ and $a\ e$, representing the entire width of the plan, which, as already stated, is in this case supposed to be square.

From d and e draw lines to the *measuring* points, cutting $a\ b$ and $a\ c$ in f and g.

From f and g draw lines to the *vanishing* points, cutting each other in h.

The figure $a\ g\ h\ f$ will then be the perspective view of the square bounding the plan.

Now within the distances $a\ d$ and $a\ e$, set off the spaces $a\ j$, $a\ k$, $d\ i$, and $e\ l$, representing the real thickness of the legs and back of the chair.

From the points i, j, k, l draw lines to the measuring points, cutting $a\ b$ and $a\ c$ in i', j', k', and l'.

From i', j', k', l' draw lines to the vanishing points. These intersecting will give the points m and n, the inner angle of each of two legs, and the same of the other two legs, which are not really visible in the present view, but which are marked o and p. This then will complete the plan, and we can now proceed with the chair.

At a erect a perpendicular of indefinite height, and mark on it the length $a\ q$, representing the real height of the seat of the chair.

From f and g draw perpendiculars.

From q draw a line to each vanishing point, cutting the perpendiculars drawn from f and g in r and s.

From r and s draw lines to the vanishing points, cutting each other in t. The figure $q\ r\ t\ s$ is then the perspective view of the seat of the chair.

Beneath the point q set off on the perpendicular $q\ u$ the thickness of the board forming the top of the seat, and from u draw lines to the vanishing points.

At i', j', and k' erect perpendiculars as far as the lines drawn from u to the vanishing points, and at l' also draw a perpendicular, which, together with the perpendicular g, is to be drawn of indefinite height.

Beneath the point u set off in the perpendicular $u\ v$ the real breadth of the framing of the chair connecting the legs and supporting the seat.

From v draw lines to the two vanishing points, observing that the framing only extends from leg to leg, but the real breadth must be set off on a, which is the line of measurement for heights, being the only perpendicular which is in the immediate foreground, and on which, therefore, the true measurements are not altered. The lines from v should therefore be dotted across the leg, and only strengthened where the framing would really be seen.

It will now be seen that the line $q\ s$ is intersected by the perpendicular drawn from l' in the point w; from w draw a line to the vanishing point, cutting $r\ t$ in x'. At x draw a perpendicular.

Now it will be seen that the perpendicular at w, which gives the one edge of the back of the chair, is a continuation of the perpendicular rising from l'; and since the perpendicular x' stands in the same relation to the side $r\ t$ as w does to $q\ s$, it should be a continuation of a perpendicular raised upon the point x, which is to $f\ h$ as l' is to $a\ g$.

Perpendiculars raised from n and p will cut $w\ x'$ in y and z, and will give the inner edges of the back of the chair.

Now on the perpendicular a set off $a\ a'$, the real height of the back, and draw a line to the vanishing point, cutting the perpendicular l' in a''.

From a'' draw a line to the vanishing point, cutting the perpendicular x in x'', and of course the distant line of the top is to be drawn in a similar manner.

From a' set off $a'\ b'$ equal to the thickness of the top of the back, and draw a line to the vanishing point, cutting $l'\ a''$ in b'', and from b'' draw a line to the other vanishing point.

The foot-rails and that in the back are drawn in a similar manner. It will be seen that the tenons are not considered here, the general thickness of each rail being only required.

CAPITAL AND LABOUR.—V.

By J. E. THOROLD ROGERS, M.A., Tooke Professor of Economic Science.

ASSOCIATIONS OF CAPITAL.

IT has been stated that the assistance which capital gives labour—in order that labour may find its market, may be continuously occupied, and may be enabled to obtain an average remuneration, because it is not constrained to sell at a forced price, but may hold that which it produces till the market is better—varies with the nature of the operation on which industry is engaged. In some cases the assistance is so considerable that the labour would never be exercised if capital, in the hands of employers, were not forthcoming for the requisite purpose. In others it is so slight that the labourer can constantly dispense with the services of the employer, and deal at once with the public, or at any rate merely employ the occasional services of a middle-man or agent. The most obvious illustration of the latter phase is that in which a small occupier tills his own land by the labour of himself and his family. Here the only purpose for which he occasionally needs the office of the capitalist is to sell him such parts of his stock as he may wish to dispose of, and for the sale of which he finds it convenient to employ an agent in preference to going into the market himself.

But, on the other hand, there are certain kinds of industry in which it is impossible for the labourer to carry on his calling without the intervention of the capitalist employer. Such cases are (1) those in which great outlay is necessary previous to the exercise of labour in the service or production on which the labour is ultimately exercised; (2) those in which the economy of production, on a large scale, is so great that no individual labour would be able to compete against combined labour directed by the capitalist employer; (3) those in which it is

particularly needful that the turn of the market should be watched, in order to prevent great changes in the price of the article, and consequently great uncertainty in the amount of employment and the rate of wages.

One of the best illustrations which can be given of the first among these operations is that of the construction and maintenance of public roads, especially those with which we are familiar, in which the minimum of friction is overcome, and therefore the greatest speed can be obtained in travel, at the least possible expense. Now the construction of railroads is an operation of so much magnitude, that it is only in this country and the United States that railroads have been made by private and joint-stock enterprise. In every other country they have been constructed either wholly or partially by the State. In the wealthiest Continental countries it has been generally the custom for the State to supply the land, and for the company to construct the line. But in most cases the State has taken in hand the construction of railways, and of course has generally borrowed the necessary capital from foreigners. The magnitude of the operation has been so immense, and the resources at the command of the inhabitants have been so scanty, or the tendency to conjoined enterprise has been so feeble, that private agency would have been insufficient for the purpose. It may be added, too, that except in countries which possess great social and political freedom, and in which the use of this freedom has long been a familiar fact, it is very difficult to develop that spirit of mutual confidence which is requisite to the success of such undertakings. Even in countries where such confidence prevails, advantage has been taken of opportunity in order to abuse public trust for private ends. Both in our own country and in the United States a special kind of dishonesty and fraud has been practised in connection with railway enterprise, to the infinite disaster of those who have been interested in these undertakings.

Speaking roughly, English railways pay a dividend, at the present time, of about 4 per cent. on the capital invested in shares. The working expenses, on an average, and in the same general way, amount to nearly as much as the dividends. Hence the original outlay of the undertaking amounts to about ten times the quantity of the annual receipts—a proportion which is far in excess of that which rules in any other business. This fact will show why it would not be possible for private enterprise, apart from association, to have undertaken these roads, even if the magnitude of the undertaking had not been far beyond the resources of any private fortune. An individual trader expects that his capital will be replaced with its profit within a comparatively limited time, and would seldom, if ever, acquiesce in employing it in such an occupation as would return it only after an interval of ten years or more.

It may be worth while here to notice the fact that when persons invest their savings in undertakings to which they do not give their personal attendance, supervision, or labour, the advantage which they derive from such investments continually tends to the ordinary rate of interest. In other words, persons cannot get the profits of trade unless they take the risks and undertake the labour which trade implies. At the present time railways pay a somewhat higher per-centage than the ordinary rate of interest. But up to the beginning of the year 1871 they did not on an average pay a higher rate of profit to the shareholders than that which is obtained in public securities, and this profit was certainly liable to far more risk. I mention this partly because it is an important fact, the reason of which can be easily detected, and partly because it forms an illustration of the theory which I have already laid down, that the profit of such persons as are engaged in a business to which they give their personal labour is only wages under another name.

The office of the capitalist employer is also necessary when the calling on which labour is engaged is of such a kind that great economy may be effected by the division of employments, and therefore the individual labourer cannot compete against combined labour, directed by a capitalist employer. These economies are in the main twofold. In large undertakings of the class referred to it is constantly found possible to introduce labour-saving machines on the largest scale. Take, for example, the business of a man who is engaged in supplying builders' fittings—as doors and window-frames. Ordinarily, such work is the business of a joiner; but a wood-cutting machine will turn out a door or a window-frame—which would cost a day's work to the joiner—in a very few minutes, and will execute the work with almost mathematical precision. The planing machine of the machinist, employed to bring the surface of iron castings to the smoothness requisite for a well-constructed machine, is so prodigious an economy that no hand-labour could possibly compete against the machine. The second economy is that of classifying labour. In a great glass manufactory there are several classes of labour, the wages of which vary from pounds a week to shillings. If the industry were carried on by an individual, even if the individual were able to supply the costly plant and furnaces needed for the manufactory, it would be necessary for him to do the cheapest or meanest, as well as the dearest and mostly highly skilled labour himself. The waste of such a system is manifest.

In these callings, as the economy of a great as opposed to a small undertaking is manifest, there is a growing tendency to associate a large number of capitalist employers together, or, in other words, to turn private business into joint-stock enterprise. For the reason which I have given above this tendency will, I think, be temporary only, for it will very rarely be the case that joint-stock enterprise, unless it involves exceptional risk, will pay a much higher income than the ordinary rate of interest to those who engage in it.

Lastly, there are callings in which the turn of the market has to be carefully watched. Perhaps no better illustration of this kind of business can be given than the calling of a publisher of such books as are issued in order to meet the taste or caprice of the public. I cannot conceive the development of the joint-stock system among authors, or even among those who act as intermediaries between the author and the public. But it is quite certain, whatever may be the difficulties which lie in the way of any association of capitalists in this business, that there is no article in demand the value of which is so precarious as that of a book is, unless, of course, the reputation of an author is so great that he can afford to write nonsense.

PRACTICAL APPLICATION OF THE FINE ARTS.—XIV.

By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING.

CLASSIFICATION OF BINDINGS—MATERIALS FOR BINDINGS.

Leathers.—Bindings are classed according to the outside cover. This may consist of various leathers, cloth or paper. A book may be whole-bound or half-bound. The whole-binding naturally means that the whole of the cover of the book is covered with the same leather. The half-binding is understood to mean that the back and corners of the book are covered with some leather, whilst the side simply has cloth, paper, marbled or otherwise, pasted on the boards : we have seen a book half-bound in Russia, with vellum sides.

Paper is only used for the commonest and cheapest of books, such as cheap novels. These paper covers are usually printed and ornamented with pictures or titles, and they are most frequently pasted first on the boards and back, and the whole, boards, back, and paper cover, attached to the book after it has been stitched and cut. This, of course, is the cheapest and least useful kind of cover that a book can have. Formerly, books were commonly sold in what were called boards, that is, the cover was just covered with a thin kind of dark-brown paper. Since the introduction of cloth for the first covering of books, "boards" have disappeared. The Italians had a rough paper binding also, which was called *alla rustica*, but it wore out very rapidly, and soon became useless.

These various coverings were used as cloth is now used for publishers' bindings, that is, for the covers in which books are prepared for their first sale. Of course, in this case a large number are done at a time all alike, or all having much of their ornamentation in common. The process by which this is done is somewhat different from that of binding proper, in which each book receives individual attention, and is treated, as lovers of books would have it treated, like a pet child. We shall in a future paper describe the wholesale binding in cloth, so that we defer that process for the present, and treat only of the individual binding.

Morocco.—Of all the leathers used for bookbinding, morocco

is undoubtedly the best. It is a carefully-prepared goat-skin, tanned, tawed, dyed, and grained. It is stronger, more pliable, and lasts longer than any other skin. Of this leather there are various kinds, and it is prepared in various places; English, French, and Spanish moroccos all excel in their own way, either in grain or in colour. The French have the pre-eminence in the species of *levant** skins, which are called *gros grain*, and are marked with a handsome full grain of considerable size; shagreen is a smaller marked skin which they also make, but which is made in England as well; whilst the English excel in the straight grain, which appears something like the wrinkles on the back of a man's hand. This grain is made by passing a ball of boxwood, mode in which this done is unknown, and skins coloured in this manner are only procured from Spain. The effect of this style of pattern is pleasing, but it is seldom employed now, except for Spanish books. The thick, good, and strong skins of morocco frequently cost as much as £1 apiece, and they will after all serve only for the binding of one large book, as merely the best parts of the skin can be employed, though, of course, the scraps cut off can be applied to less important purposes. A thinner and cheaper kind of morocco is used for the pieces put on either as labels at the back, or for inlaying the sides of a book, but this is not suited for covering the whole of the back and boards. In working morocco after it is put on the book, it is found that

SPECIMEN OF BINDING, NO. 2.—FRENCH.

SPECIMEN OF BINDING, NO. 3.—FRENCH.

with grooves in it, over the skin many times. As regards colours, the French produce the best light colours, especially reds and blues; their reds are far better than any manufactured in this country; whilst for darker tints, especially olives, maroons, greens, and browns, the English skins are esteemed preferable. The Spanish skins are coloured in a peculiar manner which somewhat resembles marbling, one colour being laid on another, and sometimes a third added in a similar manner. The

* It is remarkable that both the terms *morocco* and *levant*, which now designate a peculiar kind of leather, manufactured in London or France, should have so far changed their original signification; but these are only two out of numbers of words, which from geographical names have become designations of manufactures, and the materials being cheaper elsewhere, the productions themselves are imported by the countries whence they take their names.

it should be prepared for the finisher by damping it. The reds are greatly improved by the addition of a little acid, whilst other colours work best when moistened with diluted vinegar, but if the colours are very light a little pure water is the best medium.

Russia.—Russia leather is prepared from various kinds of skin, and has a very pleasing odour; the appearance of the lines in it is agreeable, but it has the unfortunate peculiarity of requiring to be kept under cover; for if it is exposed to the atmosphere of London, combined with the results of the combustion of gas, it is observed that Russia very soon becomes discoloured; it dries up, and at last crumbles to powder. An instance of this kind occurred not very long ago at the Athenæum Club-house, where it was found that a large number of valuable bindings had completely gone. This is a great drawback to a species of binding that otherwise would be most agreeable.

Calf.—Calf is really what it is called, the skin of the calf, pre-

pared by the process called by tanners "tawing." The natural colour of the skin is a very light drab, but it turns darker in time, and becomes a light-brown. The uncoloured skin is pleasant enough to the eye, and is used in the peculiar style of binding called "Law," since it is commonly used for law-books. allowed to fall upon the cover, or upon a portion of the cover, the rest being protected by a covering. The copperas mixing with the tanning left in the skin produces a kind of ink, and so darkens the spot where it falls. Considerable variety may be caused by protecting various portions of the cover in patterns,

SPECIMEN OF BINDING, NO. 1.—GROLIER.

The skin, however, can be dyed any colour, and it has then an agreeable appearance, but as the mordants used in the dyeing are apt to attack the leather, and cause it to go more than it otherwise would have done, the best style of decoration for calf is the colouring of the natural skin by the binder. There are various ways in which this is done. It may be sprinkled wholly or in part. This is effected with a hog's-hair brush, dipped in a strongish solution of copperas (protosulphate of iron) in water; the brush is scratched with the nail, and the small drops are and graduations of the colouring can also be effected. Another mode of colouring is called *French catspaw*. This is produced by dipping a piece of wool, or similar substance, in the colouring matter, and dropping it on the cover, thus forming a more or less regular series of patches of dark colour. A third style of ornamentation is called "tree calf." The process by which this curious style of ornamentation is brought about is almost as remarkable as the marbling the edges of the leaves. The cover, which, of course, must not be too thick, is bent upwards away

from the book into the form of a channel. This is held slanting, at an angle, say, of thirty degrees: it is then sprinkled with pure water pretty freely, until the various spots begin to run into one another, and to find their way down to the central channel, and thus to fall off the cover. At this moment some very finely powdered copperas is dropped on the wet spots, and allowed to run down with the stream. Where the water is sufficient it carries off the iron, but where the leather is only damped it allows the colour to sink down into the skin. Some little experience and neatness of hand are required to give the desired effect, and to produce on the two covers a corresponding effect, which, however, should not be too closely alike.

Vellum.—Vellum, though scarcely a leather, is a preparation from skin which is not unfrequently used for binding, particularly classical works. The appearance at first especially is very pleasing, but it is apt to grow yellow, besides, from its colour, liable to show every stain or speck of dirt. Gold ornament stands out remarkably well upon the plain white, but for every-day use such a binding is almost painful. This covering lasts very well, and is very strong. There are various kinds—the English, which is the best and strongest; the artist's, which is the whitest; the Roman; and the commonest, which is called parchment. Vellum requires very different working from morocco and the other leathers; it will not admit of inlaying, for all leathers stuck on it peel off as soon almost as they are dry. If it is desired to have colour on vellum, it is necessary to paint it, and this can be done with plain water-colours. Vellum has to be moistened with pure water with only a very little gum in it; it requires a very clean workman, and the tools have to be much cooler than for the leather.

Sheep, etc.—The other skins used are sheep, roans, and skivers. *Sheep* may be had white, and of all colours. It is much thinner than those we have mentioned before, and much cheaper. It is greatly used for school-books and works of a like character, but naturally it will not last like morocco or even calf. Sheep-skins are sometimes prepared to imitate morocco, and so successfully, that they would take in the unwary. The grain and colour are perfect, and a man may often think that he has bought a cheap morocco binding, whereas he has been put off with a sheep-skin, which costs one-fourth of the price. Calf is imitated in the same way, and to the same effect. *Roans* are prepared much like the straight-grained morocco, but they have more varnish on them, and are much thinner. These are much used for binding and for half-binding periodicals, especially those of large size. Roans can be had in all colours. *Skivers* are split skins, and are very thin; they used to be much employed for Bibles, prayer-books, and school-books, and then frequently embossed—that is, stamped with a pattern before they are fastened to the covers. *American cloth* has been used, but it is very weak, and is now only employed in the cheapest forms of Bibles and prayer-books.

Velvet and Silk.—Occasionally velvet has been used for covers of books, but, naturally, this is rare, since it will not stand much wear. Silk also has been employed, but this is much more frequently found in the inner sides of the boards, which are sometimes as much ornamented as the outer. We have seen both vellum and morocco used for the interior, but the latter has the disadvantage, that it always contains some fat, which, after a time, works out and stains the opposite page. Several specimens of velvet and other rare bindings may be seen in the open cases in the King's Library, in the British Museum. Amongst others, there are some, of which the covers are embroidered; we may instance a Harmony of the Four Gospels, bound by Mary Collet, for Charles I., in 1635; twelve paintings upon vellum, by Julio Clovio, of the victories of Charles V., are bound in purple velvet, and kept in a blue morocco case; this belongs to the Grenville Library, the whole of which is preserved in excellent bindings. Of embroidered velvet we may instance Queen Elizabeth's copy of Archbishop Parker's "De Antiquitate Britannicæ Ecclesiæ."

We have now detailed all the various coverings ordinarily put upon books, except the commoner sorts used by publishers, viz., cloth and paper; but as the binding with these is a distinct art, requiring in many points a description to itself, we shall reserve this for a future paper, in which we shall also give some account of the stove and tools used by the "finisher" in ornamenting the back and sides of a book with lines and figures of various kinds in gold.

PATENTS AND PATENT LAW.—II.

By A Barrister.

A PATENT: WHAT IT IS, AND WHAT ITS SUBJECT MAY BE.

We now proceed to discuss what a patent is, and what may be the subject of a patent. According to ordinary acceptation, the word "patent" is taken to signify either the letters patent by which the monopoly is granted, or the subject-matter of the grant; but the best definition speaks of it as merely an abbreviation of "letters patent," that is, open letters (*patentes*). A patent, in this sense, therefore, is the grant by the State of the exclusive privilege of making, using, and vending, and authorising others to make use and vend an invention. The monopoly so granted may be unrestricted in geographical extent, and thus be co-extensive with the authority of the State or Government granting it; the period for which it is granted is now limited to fourteen years, subject to prolongation, by order of the Privy Council; and it may be either absolute, or subject to certain qualifications and conditions. The Patent Law Amendment Act provides that all letters patent for inventions shall be made subject to the condition that the same shall be void, and that the powers and privileges thereby granted shall cease at the expiration of three and seven years respectively from the date thereof, unless there be paid before the expiration of the three and seven years respectively certain stamp duties mentioned in the Act. These stamp duties are in substitution for the fees and duties which were previously payable on taking out a patent. Further, it may be limited to the patentee personally, or extend to him, his personal representatives and assigns.

The early statute of James I. used simply the word "manufacture" as the subject-matter of patents—manufactures which others at the time of making such letters patent did not use—and that word was generally understood to denote either a thing made which is useful for its own sake, and vendible as such, as a medicine, a stove, a telescope; or to mean an engine or instrument, or some part thereof, to be employed either in the making of some previously known article, or in some other useful purpose, as a stocking-frame, or steam-engine for raising waters from mines. The French law extends to every invention or discovery, and in any kind of industry; and yet the practical construction of the English, French, and American law, in regard to the kinds of inventions that are patentable, is substantially the same. It will be observed that utility is essential to the life of a patent, and the reason is obvious. The monopoly which is granted to the inventor, is not so much for his own benefit as for the benefit of the public, who encourage him by rewards to make known his secret discovery. There can, as a general rule, be little difficulty in deciding whether an invention is useful or not, but doubt may exist, as appears by a recent case before the Privy Council, where a prolongation of the monopoly was refused, the presumption as to utility being against the invention. And inventors may take it, that before incurring expense, they should be tolerably certain of the utility of their discovery, and that they shall be able to carry it into practical operation. The case in the Privy Council to which we refer had reference to improvements in electric conductors, and in the means of insulating electric conductors; but two large companies refused to adopt it, and for the whole of fourteen years it lay unused, the consequence of which was that the patent altogether lapsed.

The statute of James I., to which we have already referred, while it abolished monopolies generally, made an exception of existing letters patent and grants of privilege for the term of "one-and-twenty years or under, of the sole working or making of any manner of *new* manufacture within this realm to the *first and true inventor* or *inventors*, so they be not contrary to the law or mischievous to the State, or generally inconvenient;" and also an exception of future grants of letters patent for the term of fourteen years or under. Here we see that another essential of a patent is novelty. The subject-matter of a patent must be useful and new. But novelty must not be taken to mean new in all details, inasmuch as a patentable invention may be a new combination of materials previously in use for the same purpose, or a new method of applying such materials. This fact, however, must be made clearly to appear, as the mere application of a well-known process of casting to an article previously well known has been held not to be the subject of a patent. A very good illustration of legitimate operations in

this respect is afforded by the discovery of electricity, which has presented a variety of applications to practical purposes, and opened an immense field for the granting of patents.

An important consideration arises as to the period to which the term "novelty" is to apply, and it would seem sufficient if it appear that the thing patented had not been known or used before the *invention* by the patentee, as distinguished from the time of his application for a patent. The actual issue as to novelty is not so easily decided as might be supposed, and may present a difficult problem of mixed law and fact for solution by the judges. So closely may different descriptions apparently refer to the same subject, and yet in truth refer to inventions having different operations, that it is only by careful inquiry that novelty can be established or disproved. In one case, it was laid down, that even if there be identity of language in the specifications, yet if there be terms of art in one and also terms of art in the other, it is impossible to predicate of the two with certainty that they describe the same identical external object, unless it is ascertained that the terms of art used in the one have precisely the same signification, and denote the same external objects, at the date of the one specification as they do at the date of the other. Therefore, evidence must be forthcoming on these points. Further, an invention may be novel which is new in its practical operation, though the theory upon which it rests has been described in a prior specification. Thus, it has been distinctly held, that a notion that tin and lead might, by means of pressure, be so combined as to form a new and useful material, without giving information how to attain that object, is no ground for invalidating a subsequent patent giving that information. In delivering judgment in that particular case, the then Lord Chancellor was very precise, and well states the established rule, "that a barren general description probably containing some suggested information, or involving some speculative theory, cannot be considered as anticipating, and therefore as voiding for want of novelty, a subsequent specification or invention, which involves a practical truth, which is productive of beneficial results, unless you ascertain that the antecedent publication involves the same amount of practical and useful information."

An interesting illustration of what has been said on the subject of novelty has reference to chemical processes, and it has been distinctly held that where a patent has been taken out for improvements in the mode of producing a chemical substance, it is no bar to the legal validity of the patent that the subject of the patent is a product already known to scientific men, provided the patentee is the first person who has produced the substance in a sufficient quantity to make it a marketable article. And it was further decided in the same case that it is no bar to the validity of a patent for improvements in the mode of producing a particular substance that similar processes have been employed to produce analogous substances, where the subject-matter of the production is a chemical product, and the process is a chemical process. And further, that where the subject-matter of an alleged invention is an improvement of a chemical process for the production of a substance, a patent specifying a particular limit of temperature to be used in the process may be valid. But there cannot be a patent for a philosophical principle only.

We should occupy too much space were we to elaborate this particular branch of the subject by referring to the numerous decided cases, and we will now proceed to another necessary condition to obtaining a patent. The applicant must be, in the words of the statute, the "first and true inventor." The inventor within the meaning of the patent laws has been described to be the man who discovers the mode of producing the substance or material in such a form, and to such an extent, as to make it useful to the public at large. He is not the inventor who merely suggests, unless, indeed, he suggest the actual process or machine. If the specific process is pointed out, the person to whom it is pointed out cannot afterwards be the inventor. In an action by a patentee for an infringement of a patent for a bleaching liquor, a chemist deposed that previously to the granting of the patent he had had frequent conversations with the patentee on the means of improving bleaching liquor, and that in one of them he had suggested to the patentee that he would probably obtain his end by keeping the lime-water constantly agitated; it appeared that this was indispensable in the process, and consequently Lord Ellenborough refused to recognise the patentee as the first and true inventor. Again, where a workman made an improvement, and his master patented it, the latter was held not entitled to sue for an infringement. But it is a question to be decided, upon consideration of the particular circumstances, whether the inventor by the nature of his employment, or by his contract, either assigns his invention to his employer, or at least divests himself of his property in it. If a person is employed for the express purpose of devising improvements, anything which he invents in the course of his employment is, it appears, the property of his employer.

A difficulty may suggest itself where there are simultaneous inventions by different persons. The case has arisen and been decided, and the decision is that he who first publishes his discovery by obtaining a patent for it will be the true and first inventor within the meaning of the statute, although he may not actually have been the first to make the discovery. Then again, is a person who obtains information abroad, and takes out a patent in this country, the first and true inventor? He is, and it is no objection that the patent is taken out in trust merely for the foreign inventor. But by a recent enactment it has been expressly provided that where letters patent are granted in the United Kingdom for any invention first invented in a foreign country, or by the subject of any foreign State, and a like privilege for the exclusive use or exercise of such invention in any foreign country is there obtained before the grant of such letters patent in the United Kingdom, all rights and privileges under such letters patent shall (notwithstanding any term in such letters patent limited) cease and be void immediately upon the expiration or other determination of the term of the like privilege obtained in such foreign country; or where more than one such like privilege is obtained abroad, immediately upon the expiration or determination of the term of such privileges which shall first expire or determine. And no letters patent granted for any invention, for which any patent or like privilege shall have been obtained in any foreign country, shall be of any validity if granted after the expiration of the term for which the foreign patent or privilege was in force (15 & 16 Vict., c. 83, s. 25).

Before proceeding, as we shall do in our next paper, to show how letters patent are obtained, we may mention generally that they are not by any means granted as a matter of right. The granting of letters patent is a prerogative of the Crown, and although a patent may now be always obtained for a new invention, yet the grant is still a matter of favour, and not of right, and all grants are clogged with certain conditions, to which we shall have to refer in some little detail. And when granted for the period allowed by the statute, the question of prolongation is one purely of discretion for the Privy Council. In a very recent case, the specification of a patent described it as an improvement in treating, deodorising, and disinfecting sewage and other offensive matter, and also for deodorising and disinfecting in general, and as being composed of two ordinary well-known chemical acids in combination, such acids being in common use for disinfecting purposes by the public before and after the letters patent. The invention was held not to be of such merit as to justify an extension, to the detriment of the public in the use of known sanitary agents. The Privy Council, however, has a fixed limit of fourteen years, beyond which it cannot grant a prolongation of a patent, and it may determine to grant an extension to any shorter period which the nature of the invention may suggest.

MAP AND PLAN DRAWING.—IV.

By C. C. King.

DELINEATION OF SMALLER AREAS.

In the previous papers we have very briefly examined the method on which surveys of large areas are conducted. Even when we have unlimited time and means at our disposal, so important is this branch of map-making, that great care and the most accurate instruments are required to efficiently carry out the operations. But in the delineation of smaller extents of country the chances of error are reduced; and in the construction of these plans less perfect means are employed, though, at the same time, care is equally necessary, and sufficiently correct

results can then be obtained for all practical purposes. It is not, however, advanced that the theodolite and level are unnecessary in this work, for whenever time or opportunity is afforded they may be used with advantage; but we shall endeavour to point out how, with very portable instruments, the survey of a small area is conducted, and how, with care, such may be both valuable and approximately true. We have, in defining the difference between a map and plan, described the latter as the representation of a less extensive tract than that to which the former applies; and plans, again, may be of two kinds—one of a comparatively large area, when it approaches the magnitude and nature of a small map, and when the method of construction will assimilate very nearly to that of a map, or the sketch of a very small space of ground, as, for example, a village or estate of a few acres, where triangulation would be perhaps difficult, through the want of prominent features, and in many cases unnecessary, as the distances could be accurately measured without going through the labour of ascertaining them by trigonometrical calculation. The second case, in fact, merely comprises the work done in the concluding portion of the first or larger plan—that is, in one instance the principal points or "bench marks" are determined by triangulation, and in the other by absolute measurement, if it appears to save time and trouble during the operations of "traversing," which will be explained later.

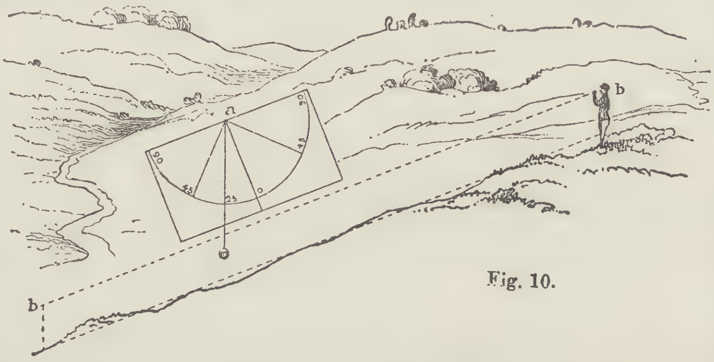


Fig. 10.

The instruments to be employed will necessarily have to perform the same kind of work as in more extended surveys—that is to say, a base has to be measured, triangles have to be constructed, heights have to be ascertained, and means of carrying out these requirements have to be provided. Those used in sketches of this sort are the prismatic compass, for reading angular bearings; the chain, or even a well-stretched line, and carefully-prepared line, if no chain be procurable, for measuring distances; the clinometer or orometer, for levelling and finding altitudes; and, lastly, a plotting-book and sketching-case.

In map making, that is, in extensive delineations, the "plotting" or note-book is alone used, as it would be impossible to transfer the work done in the field actually to paper, because of the size of the measurement; but in the present instance the plan, with any ordinary scale, is sufficiently small to come within the limits of a moderately-sized sketching-case; and though the note-book may be used to check the observations, it is advisable to transfer the work done, especially if time be an object, immediately to the field sketch, from which, if it be afterwards required, a copy can eventually be made. The plotting-book is a simple rectangular note-book, some few pages of which may be ruled to put down the series of angles in a triangulation, in the manner exhibited in the accompanying model;

STATION.	1st Observn.	2nd Observn.	REMARKS.
A	42° 15′	42° 15′ 30″	Bearing of windmill.
B	108 20	108 20 0	Bearing of St. Andrew's Church.

and the remainder ruled on each page, with two parallel lines which run along the centre of each page and divide it into three equal, narrow spaces, the use for which will be explained further on. The sketching-case may be of any form, but the most convenient kind is that which is provided with a slight metal frame for keeping the paper down in its place, on a pasteboard block, and which is further provided with a cover of some waterproof material, capable of being secured by elastic bands, over the sketch, and also with a leather strap at the back of the case, for the purpose of slinging it over the shoulder or round the neck, thus leaving the hands free for using instruments. The paper for prismatic compass work is ruled either in pencil or with pale-blue ink, with a series of parallel lines at irregular intervals. This is designed for the use of the prismatic compass and protractor, as will be seen in describing the method of depicting the work done. The protractor is a rectangular piece of ivory or wood, the edge of which is divided into 180°, and which has also a series of equidistant lines ruled on it, parallel to its shorter side. For convenience' sake a few scales, such as would be most generally useful in work of this nature, are marked on one side of the protractor.

The chain has been described in former papers, but any piece of well-stretched and carefully-dried cord can be used, and sufficient accuracy arrived at by repeated measurement. In many cases the pace of the surveyor is used for determining distances; and in military work this is invariably employed to a large extent; but care must be taken that the pacing is regular, and that allowance is made for irregularities of ground in ascending or descending hills or valleys.

The clinometer is a portable instrument for measuring inclinations of slopes, or even for tracing a horizontal contour line through the district; but as it is carried in the hand, and is therefore susceptible of any sudden irregular movement of the operator, and is also liable to be disturbed by wind, great care is required in its use, and the results arrived at by it are necessarily only approximately true. There are many varieties of clinometers, the simplest and most general form being a rectangular piece of wood or cardboard, three sides of which are graduated in degrees, on an arc of which the middle point of the upper long side is the centre; and to this point is attached a silken cord and plummet which, hanging vertically, aligns itself with one of the angular divisions and indicates the slope at which the upper edge is inclined. There are two methods of using it, either by making the upper edge parallel to the slope of a hill, seen as it were in profile (Fig. 10, *a*), when the flat side of the instrument is towards the observer; or by looking along the upper edge, either up or down hill (Fig. 10, *b*), and when its prolongation passes through a point the same height above the slope observed as the eye of the operator, reading the angle indicated by the plumb-line. It is evident, in the latter case, that practice is essential to ensure the upper edge being in a plane parallel to the slope of the hill. For contouring it is simply necessary to keep the plummet vertical through the zero point, which is immediately opposite to that whence the cord is suspended, and then notice where the prolongation of the top side of the rectangle, which is therefore horizontal, meets the sides of the hills or valleys (Fig. 11, *c*). These points should be marked temporarily by a stone or picket.

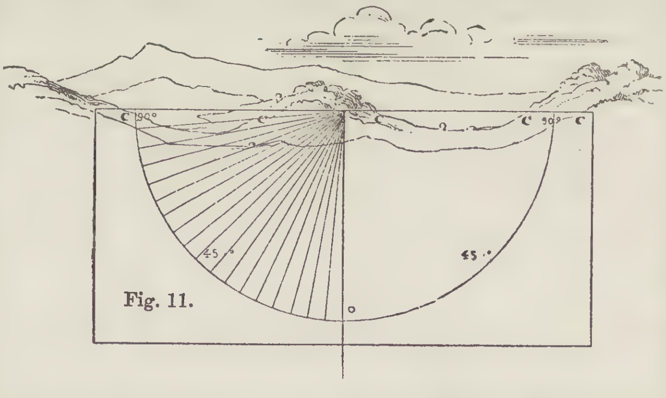


Fig. 11.

From the clinometer we will now pass on to describe the prismatic compass, which is, as its name denotes, an instrument for measuring angles with reference to the magnetic meridian. There is a great difference, therefore, between a series of angles taken by it and by the theodolite. With the latter the round of angles is taken with reference to the line on which the zero point of the instrument is directed. Thus, if the theodolite be placed at one extremity of a base, and the telescope be directed on the other extremity, the angles will be measured from that base, and will be those contained between it and the lines joining the several points observed with the station on which the instrument is placed. But in using the compass, the angles taken at any period have reference to the magnetic meridian, and are those contained between it and the lines uniting the observed points with the surveyor's position. It consists of a brass box, in which is a common compass-card, capable of free movement on a needle-point. The edge of the card is graduated in degrees from zero to 360°; and as these are read through a prismatic sight attached to one side of the box, the numbers are printed the reverse way. This prism is contained in a small brass case, working on a hinge, so as to admit of its being brought vertically over the edge of the compass-card, and has, when so placed, a notched "sight" on its upper surface. Immediately opposite this sight, and on the line, therefore, passing from it through the centre on which the card turns, is a small brass frame, which moves on a hinge, so as to bring it into a vertical position, and which contains a fine wire, carefully aligned by the maker, at right angles to the plane of the compass when held horizontally. Thus, if the eye be kept close to the notch of the prism, and the line of sight be directed, by means of the wire, on any given point, its bearing with reference to the meridian can be read on the card, through the prism, without removing the eye from the sight. The compass having free movement, is always seeking to point to the magnetic north, and to check its oscillation and cause it to remain stationary in that direction, a small spring, which can be pressed against the edge of the card by the finger of the operator, is attached to the front side of the box. For field-work a good pencil is an absolute necessity, and for all ordinary purposes, an F or a HHH, if good, are the best kinds, with perhaps a darker one, in case any of the hill shading is done in the field; and as a practical fact it is advisable that these, together with the india-rubber and penknife, should be attached by cords to the sketching-case, as the surveyor frequently works independently, and in moving over rough ground may suddenly find himself unable to continue his work, owing to the loss of his materials for noting down or transferring to paper the observations and results he has obtained.

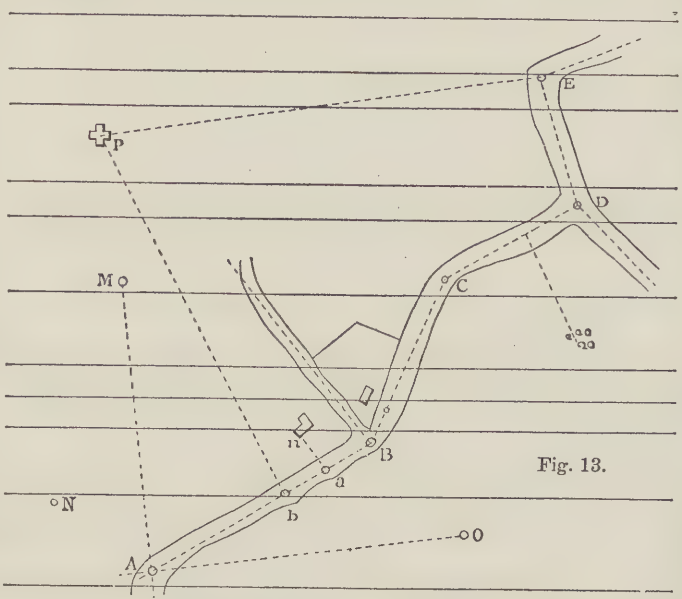


Fig. 13.

Let us assume, then, that the surveyor having walked over the area he intends to survey, so as to acquire a general knowledge of its features and of its extent, has finally selected a piece of tolerably level ground, conveniently situated in a somewhat central position, on which to measure his base. Choosing two points as far apart as possible (for on the length of the base much of the accuracy of his sketch will depend), and from which a tolerably numerous series of points can be seen, he marks them by pickets firmly planted in the ground, and proceeds to measure or pace the distance between them as often as may appear necessary. Should there be much difference of level between them, the angle of depression will be measured by the clinometer, and the base transferred to a horizontal plane by a simple trigonometrical calculation.* It is not absolutely requisite that the base should be so situated as to admit of all the prominent points in the neighbourhood being visible from its extremities. It may happen that the most convenient site for it is in a valley; but from it one or two points that afford a more extended view should be apparent, probably on nearly adjacent hill-tops, and these, when carefully determined by observation, will constitute, in some respects, a secondary base.

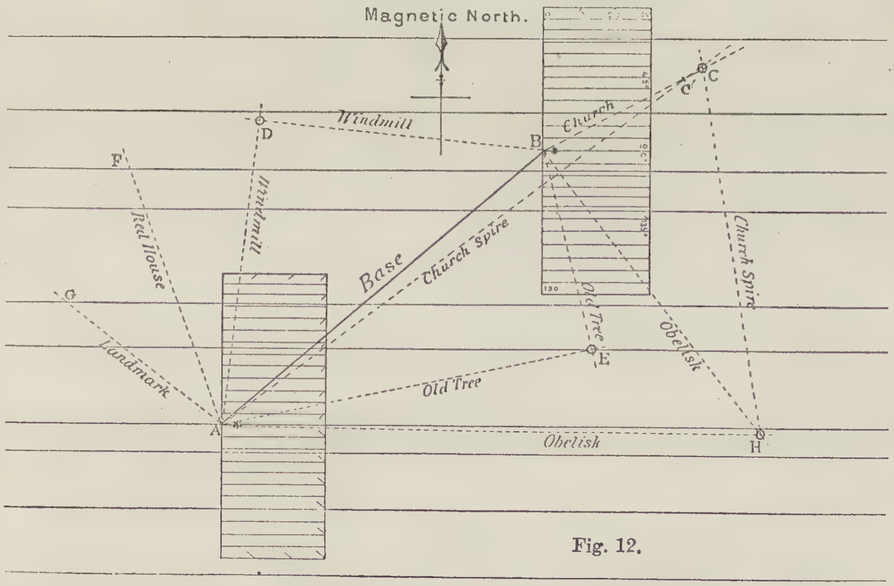


Fig. 12.

The magnetic bearing of the base is then observed, and according to the selected scale the base is transferred to paper.

* The required distance in this case is manifestly the base of the triangle, of which the actual measurement is the hypothenuse, and the angle at the base that ascertained by the clinometer.

The blue or pencil lines ruled on the prepared sheets are usually considered as magnetic east and west lines, and all lines at right angles to them are therefore magnetic north and south. Marking any convenient point on the paper to represent one extremity of the base, the protractor is placed with the zero mark at this point, and with *one* of the transverse lines marked on it coinciding with, or exactly parallel to, one of the ruled lines. Thus the edge of the protractor is north and south, and any angle measured will therefore represent the position of a point with the given bearing from the magnetic north. Thus, let the reading of the compass give 50°; then if the protractor be placed with the zero point at the point A (Fig. 12), and a mark be made opposite the given angle at B, the line A B will give the required direction of the base. Measure off the length of the base as ascertained according to scale in the direction of from A to B, and the first step in the work is completed.

From both ends of the base a series of angles may be taken at the most prominent points, and though as many as possible should be seen from both positions, as many others, which are only visible from perhaps one of the two extremities, should be observed and transferred to the paper. The process is similar to the previous one; but in marking off the various angles a pencil remark should be affixed to each, denoting the nature of the object referred to, so as to prevent confusion. As many points as are seen from both ends of the base will now be fixed by the intersection of the bearings. For example, the points C, D, and E have been determined, but not F or G, which are only seen from the point A (Fig. 12), and are therefore fixed by bearings from other points afterwards determined. In order to correct the work, and not be at a loss in case by accident any portion of the drawing should become erased, the angle should be noted in the note-book; and in this first series more than one set of observations should be taken.

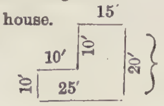
POSITION.	1st Obsn.	2nd Obsn.	REMARKS.
Point B (east end of base)	230°	230°	Point A. West end of base.
	275	274	Windmill.
	62 30′	62	Church spire.
	196	196 30′	Old tree.
Point A (west end of base)	6 30′	6 30	Windmill.
	53 30	53 30	Church spire.
	79	79 30	Old tree.
	341	341	House.
	307 30	307 30	Landmark.

Leaving the pickets marking the base still in the ground, and distinguishing them by attaching to them a piece of paper or some conspicuous object, the surveyor then proceeds to one of the points already determined, and from it takes a series of angles embracing not merely those points already fixed, but such others as from their situation will give stations as nearly as possible equally distributed over the area. These are again transferred to paper and the note-book, and the most important places having been thus visited, a number of intersecting lines, bearings taken from different points, will give the relative positions of all the noticeable features, and enable them to be accurately laid down. It does not follow that all the bearings of any one feature will of necessity pass through the same point, as it is extremely difficult, if the lines cross at a very acute angle, to determine the exact point of intersection; but the mean of the observations should be taken, and the preference given to the points determined by lines that cross nearly at right angles.*

The next operation is that of tracing, or, as it is technically called, "traversing" any roads that may intersect the area, or if none be present, a line passing through that portion which contains the largest number of minor, natural, or artificial peculiarities. Any convenient place may be selected for the starting-point; and this, if it should not happen to be a station already fixed by bearings, may be readily marked on the plan by "interpolation." The bearings of two or three of the points previously determined are taken and noted down. These angles are then laid off from the points on the paper to which they refer, and the prolongations of these lines will give, by their intersection, the true place of the observer. Thus, in Fig. 13, if the road there traversed did not start from a known point (N), the situation of A would be ascertained by taking bearings of M and O, and measuring off the angles at these points: it will be seen that their intersection gives the required station. In commencing the work, the bearing of as much of the road as may chance to be nearly straight is taken and laid off on the paper, a definite point being selected on which the instrument is directed, and the distance to this point is then either measured or traced. On arriving at the termination of this measurement a second bearing is taken, and the same course pursued, and so on till the entire road is completed. In proceeding thus, however, many objects within a short distance of the road, or actually adjacent to it, are passed, and these are successively noted down, a halt being made in measuring when such a feature is reached; and if far off, a bearing is taken only; but if near, the actual distance in this direction is ascertained. If the objects be houses, or, in fact, anything that is very near the road, the halt may be made when it is, as nearly as can be guessed by the eye, at right angles to the line traversed. In Fig. 13, a halt is made at *a*, where a house is bordering on the road, and the distance *a n* measured or paced. Again, at *b*, the bearing of the church spire P is observed, but as it is somewhat remote from the path, its position is not determined by measurement, but by the intersection of this observation, and another taken at E further on. All details that can be examined in passing along the road should be measured and noted down, but if the operator is working alone, care must be taken that the point up to which his last measurement on the traverse was taken should be distinctly marked before he proceeds to the determination of the distances or dimensions, technically called "offsets," on either side.

In all this work, even if it is actually pencilled or "plotted" on the sketching paper, the note-book should be used, as much of the detail had better be drawn at a later period, to prevent the danger of the work being rubbed out.

The note-book, divided, as we have before indicated, into three equal parts, is opened, and the first entry made on the last page at the bottom, and the succeeding entries written up the page, reserving the right-hand side for those remarks which apply to that side of road, and the left for those in the other direction, while the bearings of the successive stations in the traverse are entered first.

	Station E.	
Church bears 262° 30′.	⊙	
	140 yds.	
	343° 30′	Road bears 133° 30′. Width, 20′. Banks and ditches.
	⊙	
	Station D.	
	160 yds.	
	100 yds.	Clump of trees. Bears 153° 30′. Distance 130 yards.
	61°	
	⊙	
	Station C.	
	190 yds.	
Brick wall.	110 yds.	
Corner of house. Wood, 60′+30′.	40 yds.	
	25°	
Road bears 321° 30′. Width, 15′. Metalled. Hedgerows.	⊙	
	Station B.	
Corner of house. Brick.	260 yds.	
	210 yds.	
Church spire bears 330°.	165 yds.	
	59°	
	⊙	
	Station A.	

It will be noticed that the total measurements from the point whence the last traversed bearing was observed to each halting place, are written down, and *not* the intermediate distances; and the same plan should be adopted in transferring the work to paper, as it prevents errors in drawing. For example, in marking down the position of points *b*, *a*, B, in Fig. 13, the distances A *b*, A *a*, A B, are marked, and not the distances A *b*, *b a*, *a* B.

* Thus the point C (Fig. 12) is better determined by the bearings B C and H C than from B C and A C, which appear to intersect at C′. H is determined from A and B.

All the roads are thus gradually drawn on the sketch, and the greater portion of the information we are seeking to obtain has then been relatively traced on our plan, without reference, however, to the physical irregularities of the terrain. It remains, therefore, to complete the work by representing the character of the country, and by fixing the altitudes of the different features in it.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVII.—CHARLES VON LINNÉ OR LINNÆUS.

BY JAMES GRANT.

THIS distinguished naturalist was born on the 3rd of May, 1707, at Rashult, a village in the province of Smaland in Sweden, where his father, Nicholas Linné or Linnæus, was pastor. Charles he destined to be his successor in the pulpit, a hope which was never realised. The old man was a professed lover of flowers, and in the little garden attached to his parsonage he contrived to collect and to cultivate no less than 400 specimens of plants, most of which were of foreign growth; so this darling passion of the parent was reproduced in the son, who, for want of playmates, made the garden the circle of his juvenile diversions, save when he wandered into the woods and fields in search of plants and flowers to enrich it. His father, in his hours of leisure, taught him Latin, theology, and geography; and further, to qualify him for the pulpit, sent him to school at Wexio in Smaland, in 1717.

There the slowness of his progress induced the professors of the college to furnish him with such poor testimonials, that his father lost heart, and resolved to apprentice him to a cobbler, a result which was prevented by Johann Rothman, a physician of Wexio, who, having detected the bent of mind in young Linnæus, urged that he might be permitted to study physic and botany. On this new career he entered with ardour, and Rothman became his teacher, and Tournefort's "Institutiones Rei Herbariæ," which he found in the worthy doctor's library, became, as Stoever tells us, "the torch which illuminated the path of the youth, and opened new prospects to his eager views."

On completing his twentieth year, he resolved to attend a university, and the slenderness of his means compelled him to fix upon that of Lund, in the province of Scania, where Kilian Stobæus, who was then professor of physic and botany, became as an oracle to Linnæus, and perceiving that his circumstances were poor, he kindly took him as a free-boarder into his own family. After studying botany hard day and night at Lund, he took his departure for the greater university of Upsala, at Michaelmas, 1728. Scanty though his means, he pursued his studies there with ardour, but the end of the year saw him without the smallest means of subsistence. His father was too poor to aid him, but his kind-hearted Swedish fellow-students did. Among them he picked up a meal here and there, and was glad to accept their cast-off clothing, while necessity compelled him on more than on one occasion to cobble his own shoes; thus having recourse to the very trade with which the old pastor of Rashult had threatened him. On the arrival of the learned Olaus Celsius, professor of divinity, this state of poverty was ameliorated. He received Linnæus into his house, and obtained from him much valuable literary assistance in the compilation of his "Hierobotanicon."

It was about this time that Linnæus conceived his great idea of creating a new system of botany, and by attending closely to the position or connection of the stamens, or male organs in plants, he arranged all vegetables under one of twenty-four classes, and each class into two or more orders. He showed that the *stamina*, or dust-threads, were the male, and the *pistilla*, or dust-ways, the female parts of the plants. The sexes of plants now occupied his thoughts day and night, and this new system, of which he was the founder, began to attract the attention of the learned world.

"The system of Linnæus rests," says Figuier, "upon the consideration of the organs of fecundation—organs almost overlooked until then, but whose physiological functions have since been ably demonstrated. He introduced at the same time a salutary and much-wanted reform into botanical language and nomenclature, defining most rigorously the terms used to express the various modifications and characteristics of the organs, and reducing the name of each plant to two words, the first *substantive* designating the genus, the second *adjective* designating a species of the genus. Before his time, in fact, it was necessary to follow the name of the genus through a whole sentence in order to characterise the species, and in proportion as the numbers of the species increased, the sentences were lengthened, until it seemed as if they would never come to an end. It was like the confusion which would arise in society if, in place of using the family name and surname, we were to suppress the baptismal name, and substitute for it an enumeration of many qualities distinctive of the individual; as if, for example, in place of saying Pierre Durand or Louis Durand, we said Durand the great sportsman, or any other phraseology applicable to the qualities of the individual. Nevertheless, the Linnæan or binary nomenclature is one of the great titles to that glory which has been awarded to its immortal author. In the outline of the Linnæan system it has been found possible to describe all plants discovered since his time—an irrefragable proof of the great merits of this artificial classification of species." But although the new mode adopted by Linnæus did much to simplify the science of botany, there were defects in it which Linnæus himself soon detected by the force of his superior genius, but which even he himself was unable to rectify entirely.

In 1731, when the Academy of Sciences resolved to send a traveller to make discoveries in Lapland, Celsius recommended young Linnæus, who set out on horseback, and proceeded along the shores of the Gulf of Bothnia, till he reached the dreary district of Umea Lapmark. Through this province, so soon as the snow melted, he began his wanderings on foot, noting everything, the trees, herbs, animals, mountains, the dress and habits of the people, and sleeping wherever night found him, usually in the wretched cot of a Laplander. He next crossed the Norwegian Alps, a dreary journey, yet every mile of the way was full of allurements for the enthusiastic naturalist; but he was sinking with hardship, fatigue, and hunger, when on the 11th of August he reached Lulea in Sweden. He now visited Finland, Vasa, Abo, and other places, everywhere collecting plants and making notes; till, after travelling on foot and by horse more than 800 German leagues, he returned to Upsala in October, 1732, clad in a *Lapmud* of reindeer skin.

Ambitious to shine in the science he professed, and to secure the means of decent support, in the following year he began to lecture in public on botany, chemistry, and mineralogy, though he had not the right to do so, being without a degree. Information to this effect was lodged against him by a jealous rival, named Dr. Nicholas Rosen. He was forbidden to lecture, and thus deprived of all means for supporting himself. Full of rage, he lay in wait for Rosen, and as the latter left the Senate, he rushed upon him sword in hand, and would infallibly have run him through the body, had not the bystanders interfered. Rosen appealed now to higher authorities; Linnæus was threatened with proscription; yet for a time he still wandered about the streets, seeking for an opportunity of fighting Rosen, and killing him if he could; but after a time Linnæus also became a professor, and then his animosity to Rosen died away.

After another floral expedition through Dalecarlia, he began to lecture at Fahlun, where he fell in love with a beautiful girl named Sarah Moræus, daughter of a physician. He had a baron for his rival; but she preferred the young student, so did her father, who consented to their marriage, after a three years' engagement, and provided that Linnæus took his degree at some university. Here poverty was again a bar; but luckily at this juncture, a pension of sixty dollars yearly was assigned him by the University of Upsala; Sarah gave him one hundred dollars saved from her pocket-money, he left his native country to graduate in Holland, and took his degree at Harderwyk in Guelderland.

From thence he went to Leyden, where he found friends in the persons of Van Royen, the professor of botany; Lieberkuhn of Berlin, "besides Isaac Lawson, a Scotsman, whose loss (says Stoever), like that of the latter, the sciences had too early to mourn," Boerhaave, and Gronovius. At Amsterdam, in 1736, he published his "Fundamenta Botanica," in which the science of botany was reduced to 365 aphorisms. In 1751, the same work appeared under the title of "Philosophia Botanica." In his "Bibliotheca Botanica" he gave a system of botanical

researches divided into sixteen classes, extracted from upwards of a thousand books. In 1736 he was in London, with an introduction from Boerhaave to Sir Hans Sloane, the future founder of the British Museum. "He who shall see you both together," wrote old Boerhaave, "shall see two men, whose like will scarcely ever be found in the world." Sir Hans was displeased by this, and had no desire to see the old system of botanical science overturned by this new one, the sexes of plants and so forth. The chief object of the journey of Linnæus was to see the Botanical Garden at Chelsea, then kept by Philip Miller, F.R.S., who died in his eightieth year in 1771, and who, after some opposition to the new theory, finally arranged the garden on the Linnæan system. From London he went to Oxford, where the chief botanist then was Dillenius, a Hessian, who died in 1747. They conversed in Latin, as Linnæus was ignorant of English; Dillenius, whose age added to the pride of experience, utterly scouted the new system, though he highly esteemed the contriver of it.

After his return from England, the "Genera Plantarum" of Linnæus appeared at Leyden, illustrating the character of 8,000 plants. The same year a supplement to it with 60 more came out. Other brilliant works and translations of them followed; but still the great naturalist was in poverty, and the winter of 1738 found him in Stockholm, and for the sake of his daily bread he endeavoured, by the advice of his intended father-in-law, to practise medicine, but could nowhere find patients. However, on obtaining from the King the diploma of Physician to the Swedish Navy and Royal Botanist, the old doctor could no longer withhold his consent, and on the 26th of June, 1739, he married Sarah Moræus.

In 1741, to his joy, he received an appointment at Upsala. There he was to be professor of anatomy, while his old enemy Rosen was to teach botany; but the following year saw their chairs exchanged by order of the chancellor of the university. In 1745 he had the pleasure to see attached to it a botanical garden arranged under his own care, and on his own system. To profit by his lectures, students came from every country in Europe, and even from America; and during the Seven Years' War they numbered about 1,500. The Academy of Stockholm owes its existence partly to the zeal of Linnæus. He became member of the Academy of Montpellier, of the Society of Toulouse, of the Royal Academy of Berlin; at the instance of Tessin, he obtained the title of Archiater, or Dean to the College of Physicians, in 1747; and in the following year, he lost by death his father, who in his youth had resolved to make him a cobbler.

Under his auspices the royal museums were established in Sweden. In 1754 he discovered that plants were subject to a regular sleep at night like animals; and in order to surprise Nature in her wonders, he was wont to perambulate the garden and the hothouses, lantern in hand, that he might see the vegetable world in its dormant state, and there was scarcely any country in the world which he did not lay under contribution for his collections.

CHARLES VON LINNÉ OR LINNÆUS.

From the King of Sweden he received the order of the Polar Star, together with a diploma of hereditary nobility; and in 1754 he published proposals for cultivating and rendering profitable the wild and waste Alps of Lapland.

In 1772 he gave a fine proof of the vigour of his genius when, on resigning the rectorship of the university, he made a touching oration on "the Delights of Nature;" this was delivered in Latin, but was afterwards translated into Swedish; but two years later, when Lieut.-Colonel Dahlberg brought from Surinam eighty-six specimens of curious plants, Linnæus returned with ardour to his studies, and to the task of cataloguing them.

While lecturing in the Botanical Garden in May, 1774, he had a stroke of apoplexy, and was long insensible. He recovered, but a palsy affected his tongue, and at times he wrote in plaintive words in his diary:—"Linnæus limps, can hardly walk, speaks unintelligibly, and is scarcely able to write."

In the winter of 1776 his condition became more deplorable. Another stroke of apoplexy deprived him of power in his right side. Still he lingered, though his intellectual faculties were as much shattered as his frame, and his life became an intolerable burden, till his illness reached a climax of the most excruciating torture, occasioned by fever and stone. On the 10th of January, 1778, he fell into a gentle sleep, and never woke again.

He was interred in the ancient Cathedral of Upsala, where his remains lie beneath the organ, and in a side chapel in the north aisle is a fine mural tablet of red porphyry, with a bronze medallion portrait of him by Sergell. The inscription beneath denotes that this monument was erected to his memory by his friends and students in 1798, just twenty years after his death.

To the poor and needy foreign students who came to Upsala, remembering the hard days of his own youth, he left the whole of the perquisites which they must otherwise have paid him for lectures. One of the most distinguished attributes of Linnæus was his profound admiration for the divinity of God. In this he resembled Newton, Euler, and Locke. Like the last-named, he kept a diary, in which he recorded the principal events of his life. Besides this, he had began to write, in 1733, a little work, for his own warning, entitled "Nemesis Divina." Over the door of the hall in which he lectured were inscribed by his order the words, "Innocui vivite! Numen adest!" (Live guiltless! God observes you!)

His passions were strong and violent, as we have seen in his quarrel with Rosen; but his heart was open to every impression of joy and tenderness; and he loved jocularity, conviviality, and good living. His son, the younger Linnæus, who succeeded him as Professor at Upsala, was certainly not endowed with the same brilliant mental faculties; but the training he had undergone, and the ample notes and MSS. left by his father, enabled him to maintain with honour the post and the name that he inherited.

FISH CULTURE.—XI.

By Greville Fennell.

OYSTER CULTURE AT THE ÎLE D'OLÉRON, ST. BRIEUX, ARCACHON, AURAY, ETC.—PARCS AND COLLECTORS AT THE ÎLE DE RÉ.

At the Île d'Oléron, fifteen miles from the Île de Ré, slabs of stone from one foot to two feet high, by half a foot broad, are placed on the shore to collect the spat which is drifted to them from the natural beds. Unlike the process at Ré, no parent or breeding oysters are placed near the collectors, the spat being altogether derived from the natural oyster-grounds in deep water. From the fact that in no instance, so far as the Commissioners ascertained, have either foreshore cultivation or enclosed breeding ponds proved successful at any considerable distance from natural banks, or where such formerly existed, it would seem that their existence forms an important desideratum in successful culture. Instances are mentioned in the Report where, under supposed favourable conditions, cultivation has proved abortive, and where no apparent reason could be given beyond the fact that no oysters existed in the adjoining sea, or had ever been known to exist. It is reasonable to suppose that where oysters are absent naturally, and have always been so, some important conditions necessary for their development must be wanting in the water, soil, or temperature, etc.; and this would probably also militate against artificial culture. Considering the numerous oyster-banks which have existed, and still exist, the vast amount of spat annually voided, and the great distances to which it is carried by tides and currents, it is difficult to suppose that there is a square yard of our coasts that has not been visited by spawn; and it would therefore appear that in those places where oysters are not found, Nature protests, as it were, against them. In some places oysters are subject to exposure of more or less duration. In most parts of Ireland this would be attended with considerable risk from frost in winter, unless provision was made for having them submerged, as is the general practice in England.

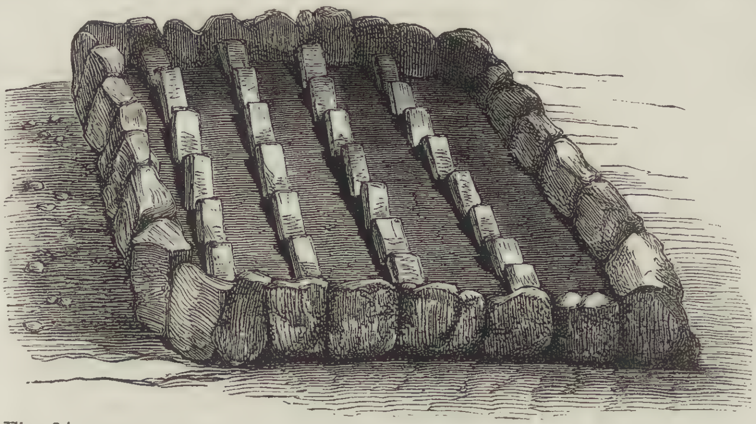


Fig. 24.—DIAGRAM SHOWING MODE OF CONSTRUCTING OYSTER PARCS AT THE ÎLE DE RÉ.

Fig. 25.—COLLECTOR OF ROUGH STONES IN OYSTER PARC AT THE ÎLE DE RÉ.

Although the cultivation is much less remunerative than it was formerly in France, still even in the depressed condition before the late war it paid better than any other industry pursued by the same class for the labour and capital expended upon it: it also possesses the advantage of interfering but little with other occupations, as the attention required to be bestowed on oysters could be given at times when labourers engaged in agriculture would be at leisure. The most encouraging instances of successful cultivation in France are to be found at L'Orient and Auray. At the former M. Charles has obtained remuneration for his capital, and at the latter M. Le Rouse has found as many as 300 oysters on one tile, and expects to profit at the rate of 20,000 francs per year. On the same river La Trinité, at Carnac, there are five other large proprietors; and seventy poor peasants, who have received assistance from the Government, have also commenced operations. All these rivers have a bottom of clay similar to that of the Essex rivers and other localities where oysters are most productive. At the Parc du Forêt, three leagues from Concarneau, the Government layings have proved successful.

The history of the origin of the Government enterprises at St. Brieux and Arcachon is of interest. In 1858, owing to the great scarcity of oysters which had prevailed for some time, M. Coste, a most distinguished member of the Institute of France, who had for some years devoted himself to the study and promotion of pisciculture, turned his attention, with most excellent results, to the promotion of oyster cultivation. By command of the Emperor, he entered into an inquiry on the subject, visited what may be called the parent source of oyster culture—Lake Fusaro, in Italy—and commenced operations in France. The result of his researches and efforts is to be found in his justly-celebrated work addressed to the Emperor, which should be read by all who desire to be conversant with the subject. It is much to be regretted that but a very brief notice of what that eminent man accomplished can be here given. One of his first undertakings was carried out at St. Brieux. This consisted in placing parent oysters, at certain distances, on the bottom of the bay, over an area of forty miles, and fascines or bundles of twigs were sunk, attached to large stones. The result exceeded all expectations, as many as 30,000 oysters being, in some instances, attached to the fascines—nearly all were plentifully covered.

Unfortunately, however, this most promising experiment was frustrated by severe storms, which covered the bottom of the bay with sand, so as completely to bury the fascines. M. Coste's next operation was at Arcachon, on the Bay of Biscay—a land-locked basin equal to about 30,000 English acres. Many years ago a very important oyster fishery had existed there, yielding annually nearly 80,000,000 oysters, valued at £10,000. As alleged, the fishery had become nearly destroyed from over-dredging. Under M. Coste's directions, in 1859, two Imperial parcs—Grand Ces and Crastorbe—were constructed. The first collectors used were wood, to which shells, etc., were attached by a resinous cement: these decayed rapidly, and were replaced by tiles, shells, and stone collectors. The first two years the proceeds were very considerable: subsequently there was a great falling off, but 1869 appears to have produced a very large crop. During six years the quantity removed from the Imperial parc was nearly sixteen millions of oysters; this was independent of the parcs of private proprietors, many of them concessions or allotments by Government, varying from one to eight acres.

A long, grass-like weed (*Zostera marina*), which grows in great quantities on the beds, proves very useful in protecting the oysters at low tide from the heat of the sun. Besides the area under cultivation, there are several natural beds in different parts of the basin, all subject to the Government regulations. The great bulk of the oysters bred at Arcachon are sent to Marennes, on the banks of the rivers Seudre and Tremblade, where the green tint so much esteemed in France is imparted to the beard of the oyster; but against which so unjust a prejudice exists in England as regards the Essex oysters, most of which are in consequence sent to France—the cause of the greenness being probably the same in both instances—the

presence of diatomaceæ, and not, as at Falmouth, owing to the presence of copper. Oysters impregnated with copper are always green in the body, whilst those of Marennes and Essex are green only in the beard or "fin."

The claires of Marennes furnish about fifty millions of green oysters per annum, and these are sold at very remunerative prices. (Bertram's "Harvest of the Sea.") The time required for fattening depends altogether on locality. At Marennes an oyster grows fat more rapidly than in the claires of the Île de Ré.

The only instance of importance of enclosed or tank cultivation in France which was visited by Mr. Francis Francis and his coadjutors was that of Madame Felix, at Regneville. Her experiments proved most successful. The enclosure is about ten acres in extent. In this 11,000 oysters were placed, and 11,000 tiles. The first year, 1864, the tiles were covered with spat, some of them having as many as 103 oysters, and the least of them about 20.

With respect to the natural oyster-beds of France, many of them became so denuded of oysters down to 1850 as to be hardly worth fishing; and some formerly of great importance—such as those of Cancale, Granville, etc.—have been all but destroyed. It was then that the French Government became alive to the urgent necessity of adopting stringent measures to prevent the threatened destruction of the comparatively few that remained on the natural banks, as well as to endeavour to replenish them where exhaustion had taken place. The laws for this object are very effective, and are fully given in the Report of 1870, but are much too long for quotation. Undoubtedly benefits accrued to the small cultivators of the soil near the sea from these grants of free shore, either for breeding or fattening purposes, and the Government encouraged such enterprises by affording facilities for obtaining stock from the Government reserves, and by occasionally making free grants both of oysters and tiles. Sailors, or the relatives and families of sailors, were allowed certain advantages over other applicants for such concessions.

Upon the causes of decline of production in France, the Commissioners state:—"The wonderful increase in the yield of the natural bed of Cancale from 400,000 in 1815 to 70,000,000 in 1847, and the subsequent equally rapid decrease, is a subject which, as it bears upon the restrictions necessary in our own country for deep sea-beds, deserves attention." Here we have, in the return, a long period of rest, and almost absolute cessation of dredging, and the fact of a vast accumulation of oysters taking place. Then follows the onset of a large fleet of boats, without restrictions, which produces, in a few years, the destruction of the bank. Comment is needless. Similar agreement in the main points is presented by the return of the public beds at Arcachon, the present regulations producing a steady improvement in the fisheries. It must be borne in mind that in certain conditions of soil, etc., the absence of dredging may be an evil instead of a benefit to the ground. Cases of this kind are those forming the subject of a Report by Mr. Cholmondely Pennell to the Board of Trade, in 1868. Mr. Pennell states that the Fish and Oyster Breeding Company have cleared 100 acres of the portion of the Blackwater estuary, and thirteen acres of ebb-dry foreshore. Of the state of this ground when it came into the Company's hands, Mr. Pennell remarks that it was, for all practical purposes, barren of oysters, and the "cultch" covered with mud and overrun with vermin and weeds. Fifty-six hauls of the dredge in 1867, before the Company was established, resulted in nine brood and spat, and nine oysters of larger growth. Recently writing in 1870, Mr. Pennell states that *two* successive gave—first, three brood, and sixty-eight spat; second haul, three brood and seventy-five spat (oysters of larger growth not counted), or an increase of 450 to 1 as compared with 1867. A stock of oysters, to the value of £11,631, had been laid upon the ground in 1868 and 1869.

The Roach River Company have reclaimed thirty acres of similar foreshore, and 270 acres of ordinary ground, and the result is equally satisfactory. In 1864, 150 hauls of the dredge gave a total of 38 oysters of all ages; and in 1869 one haul gave 100 brood and 153 spat, or an increase of brood and spat above 1,000 to 1 as compared with 1864.

That oysters cannot be dredged too much from the muddy rivers of the east coast, is the opinion of the oyster-culturist; while those who have ground in rapid and clear water, depose exactly the opposite—namely, that *rest is all* that exhausted grounds require.

The Commissioners are of opinion that all laws to be beneficial must consist of regulations adapted to the requirements of the locality, and not consist of a series of general rules arbitrarily adopted and enforced in despair of obtaining the truth when evidence so very conflicting is offered.

The foreshores at Auray, already mentioned as a success, run from the bridge to the sea a distance of twelve miles, the shores of the river being a scene of oyster culture such as it is hoped will in a few years be seen on many river-banks both in England and Ireland. The process is described as of the simplest kind. Each concession, duly bounded and marked by a numbered post or stone, contains nothing more complicated than rows of tiles, arranged so as to offer clean under-surfaces for the adhesion of the spat, which rises from the preserved banks in the river. To keep these clean, to remove all oysters of a year's growth, to lay them in claires to develop and grow, is all that is needful, and the result is entirely satisfactory. Upon the length of foreshore named no less than 88 parcs have been constructed. The number of oysters, at the time of the visit of the Commissioners, on some of the tiles was said to be 300.

We give in Figs. 24, 25 illustrations of the simple yet ingenious manner in which rude, cheap, and comparatively effective collectors were placed at the Île de Ré. These stones were procured by blasting the rocks, and they served likewise for the construction of the enclosing walls, both collectors and walls being arranged in parallel lines. The cost of a parc of 30 yards square thus constructed was stated at £12; and the number of such increased very considerably in a few years. It is now admitted by the proprietors themselves that the mud and dirt being allowed to collect upon and about these stones, and the improvidence of selling the parent oyster, and thus removing the source of the spat, were the combined causes of the present depopulated condition of the parcs.

SANITARY ENGINEERING.—XXV.

ON THE DISINFECTION OF SEWAGE ON A LARGE SCALE.

In a previous paper (No. XXI.) we have explained the *rationale* of one process adopted for this purpose, but only with reference to its limited application—viz., to house drainage. We now take up the same question upon a more extended scale—*i.e.*, with reference to large and complicated systems of sewerage, measuring perhaps many miles in length, and extending over many acres of ground. With the "products" of the sewage when "disinfected," and with their comparative commercial value as manure, we have for the moment nothing to do. The systems of sewage irrigation, where the matter is dealt with in its liquid form, are ably treated in other sections of The Technical Educator, and the details of one particular system, the A B C as it is called, have been explained at some length. Our present purpose is to describe the results of some of the most recent experiments upon a large scale, describing the various methods adopted, and giving the general result, but leaving the subject at the point of dealing with the sewage when disinfected, its commercial value, etc., which are treated by other authors under other headings. We commence by some extracts from a joint report by Dr. Letheby, the Medical Officer of Health, and W. Haywood, Esq., the Engineer to the Commissioners of Sewers, published in the year 1862, "Upon the Results of the Experiment applying Charcoal to the Sewer Ventilators." We quote from the report:—

"The district experimented upon is in the eastern portion of the City of London. It includes a space bounded by Bishopsgate Street on the west, from Cornhill to Widegate Street, by Middlesex Street and Somerset Street on the east, to the City boundary and by the Minories, and then by Leadenhall Street to Cornhill on the south—the whole of the main thoroughfares above-named being included in the area. It comprises a space of about 59 acres, with about 1,700 houses, and about 14,000 inhabitants.

"This district was selected for various reasons:—(1) Because the sewers have but a slight fall, and the currents in them are sluggish; (2) the area is densely populated, and has more than an average population of poor resident in it; (3) the thoroughfares are mostly narrow, and are therefore disagreeably affected

by the sewer gases from the ventilators; (4) the district afforded good means of isolation from other sewers.

"The total length of sewers in the district is 25,587 feet, of which 2,081 feet are pipes, and the remainder constructed of brick, varying from 3 feet high by 2 feet wide, to 5 feet high by 3 feet wide, internal dimensions.

"Wood charcoal was employed, broken into pieces about the size of a filbert. It was packed closely, but without compression, upon trays specially arranged for the purpose.

"The first air-filter ever put into action in the City was in Philpot Lane in 1859."

The report continues by saying that the deodorising power of the charcoal has been proved to be complete, and that it is patent to actual observation that the "odour of the sewer gases is not perceptible when they have traversed the charcoal."

But here we have to note one special point: the efficiency of the use of charcoal, and the length of time during which it may be safely employed, depend to a great extent upon the absence of damp. In some cases experimented upon twenty months have been allowed to elapse before removing the charcoal, and in others it has been changed at the end of a month. Local circumstances, and the completeness or otherwise of the mechanical appliances for its use, must to a great extent form the guide in practice upon this point.

The analysis of the charcoal when removed shows clearly an extensive absorption of organic matter of various descriptions; but attempts to trace the various constituents to their original source have hitherto met with very partial success.

The second branch of the inquiry has reference to the effect of the experiment upon the quantity of sewer gas admitted into houses during its continuance; but no detrimental results could be identified, and the report proceeds to recommend "charcoal respirators for workmen employed in sewers where any accumulation of noxious gases are to be apprehended." The question of cost was also reported on in full detail, which we will spare our readers, as having recorded the successful results of the experiment we may fairly pass on without further delay to other branches of the inquiry.

Having thus dealt with the disinfection of sewage gases, we now take up the question of the disinfection of sewage itself, and commence by quoting a letter conveying the suggestions and experience of H.R.H. the late Prince Consort, dated April 12, 1850.

"Leaving it to more competent judges to decide whether the sewage should be dealt with as liquid manure or solidified, upon which point His Royal Highness wishes to give no opinion himself, he has confined his attention to the latter mode of application from two causes:—

"(1) That in this shape it could be more easily transported; and (2) could be thus obtained at the least possible expense.

"The plan which His Royal Highness proposes is simply this: to form a tank with a perforated false bottom upon which a filtering medium should be laid, and to admit the sewage into the tank below the false bottom, when according to the principle of water finding its own level, the sewage will rise through the filters, and will run into the drain—if the filtering medium has been of sufficient thickness and of a proper nature—as clear as spring water.

"This medium will then have absorbed all extraneous matter, and consequently become the richest manure, which when the further supply of sewage matter is stopped, can be taken out by a common labourer with a shovel, and carted or shipped wherever desired. His Royal Highness tried the experiment on a small scale with apparent success. The medium which His Royal Highness has used is charcoal, gypsum, and burnt clay, substances in themselves highly useful as manures."

The process thus clearly foreshadowed has been adopted on a scale sufficient to test its efficiency at a large workhouse at Stoke-upon-Trent, containing about 650 inmates. The water-supply is abundant; there are water-closets and urinals, piggeries, stables, baths, etc.; and all the liquid refuse, with the rain-water of the premises, is conducted to one outfall. Previously, the whole of this sewage, about 10,000 gallons, was received into cesspools, the overflow being into the canal, which, however, produced such a nuisance, that as a consequence of certain legal proceedings, the process we are about to describe was adopted.

The sewage is first received into a depositing tank, where the heavier matter is allowed to subside, and then passes through a rough filter of coarse cinders and charcoal into a second tank, two-thirds filled with some filtering material, after leaving which it passes into a chamber in which is placed a cage filled with charcoal, which can be raised, renewed, and replaced when required. At this point the suspended matter is for the most part removed, and the sewage is then conducted through a second series of smaller filters, three in number, filled with finer charcoal and cinders, and the clear effluent water is allowed to escape into the drain. The various tanks are periodically emptied, and their contents thrown into the first tank, which is cleared out once in eight months, its contents mixed with ashes to secure dryness, and carted away to a manure factory at Newcastle-under-Lyme. The Birmingham Committee of Inquiry, who visited the works, report that they could detect no offensive odour.

It may perhaps be mentioned that the filters, though sufficient for 10,000 gallons daily, are unequal to meeting emergencies in times of heavy rainfall, when perhaps double the quantity, 20,000 gallons, have to be dealt with.

But this difficulty may be met either by enlarging the filters, or providing a reservoir large enough to contain the sewage arising from any possible flood, which might subsequently be passed through the filter by slow degrees.

At Bradford in Yorkshire works are now in progress, and nearly completed, by the Peat Engineering and Sewage Filtration Company, for dealing with the entire sewage of the town, about 5,000,000 gallons, upon this principle. The sewage will be conducted through several rows of filtering beds 700 feet long and 4 feet wide, and each particle of sewage will have to pass through 12 feet of charcoal.

The charcoal is manufactured from peat by the company above mentioned, at their works at Red Moss, under their patent, and there is practically no limit to the supply.

The charcoal when fully charged with sewage matter has considerable value as a manure, but this is beyond the scope of our present paper.

The attention of the engineers of the day, in this country and on the Continent, is now turning more in the direction of dealing with sewage in its solid form, and we recently saw some experiments in progress by which, with the convenience of a water-supply, a mechanical arrangement secured the retention of the solid matter, the surplus water being allowed to flow off by regular drainage channels, at the same time a powerful disinfectant was thrown on to the solid matter, which was subsequently removed as already described in our paper on Moule's Earth-closet System. The scheme was intended for a large Continental town, but the details are not sufficiently mature for us to do more than describe the general principle. Suffice it to say that these novel methods of treating sewage in the solid will never probably be desirable or applicable in large mercantile centres, such as London, Liverpool, or Manchester, as the immense additional organisation required would entail vast additional expense, while much of the existing drainage and other work would be rendered unavailable. If in the course of years the process becomes more extensively adopted, it would only be by the discovery of some method by which the product of the disinfected sewage would become sufficiently valuable to defray the cost of collection; but we have no hesitation in saying—and in this opinion we are supported by some of the best authorities of the day—that upon an extended scale this result has never been obtained in this country. We have read many curious particulars as to the way in which, in China, great results are obtained by the direct use of sewage matter for manuring purposes, which show clearly that under certain conditions the results are very remarkable; but the comparative states of their civilisation and our own are so widely different that no conclusion can be drawn from the facts as applicable to ourselves.

We conclude by alluding to one or two schemes for the chemical treatment of sewage, only remarking that hitherto we have no record of commercial and financial success upon a large scale.

One of these processes, as explained by Mr. David Forbes, F.R.S., "consists in treating the sewage with a solution of the native phosphate of alumina dissolved in sulphuric or hydrochloric acid. This solution is in itself a powerful antiseptic and disinfectant, completely arresting further putrefaction, and

depriving the most fetid sewage of its offensive smell; causing at the same time the supernatant water to be clear and colourless, even if tinctorial substances of great intensity be present in the liquid." This is commonly called the phosphate process. Another method employs lime, tar, and calcined chloride of magnesium, with other matters in certain proportions.

TECHNICAL DRAWING.—LXXX.

DRAWING FOR CABINET-MAKERS (*continued*).

FREEHAND DRAWING.

THE trade of a cabinet-maker is so dependent upon design, and stands in such close connection with wood-carving and other branches of ornamental art, that it will be almost unnecessary to point out the immense importance of this branch of study. Taste and refinement are called for in every article of furniture, and unless a man is satisfied to be a mere drudge —unless he would chain himself down for the whole of his life to the lowest class of work, and consequently to the lowest scale of wages—he must endeavour to improve his capabilities; he must, by self-culture and labour, fit himself for the great battle for superiority which is now going on between foreign nations and ourselves. The manual skill of our artisans is unquestioned, but they have until recent years wanted the art-culture which has been liberally bestowed on their class in other countries. Opportunities, however, are not now wanting; the noble Schools of Art and Science established throughout the kingdom are open to artisans at a charge easily within their means, and it is to be hoped that, in a few years' time, our English cabinet-makers will be able to assert, and boldly to maintain, that superiority in design and workmanship of which they have shown such great promise in the recent international exhibitions.

An important series of elementary lessons in freehand drawing is given in Lesson XLI. of "Technical Drawing" (Vol. II., page 265). To these and numerous other freehand examples given in the various courses of lessons, the student is referred, and he is urged to work the exercises carefully before attempting the following subjects.

Fig. 617.—This example presents part of the side with feet of a small work-table, which the student is advised to draw to a much larger scale, completing of course the right foot omitted in the figure.

In commencing, draw the ground-line and the central perpendicular, then the horizontal lines for the mouldings which separate the side from the feet.

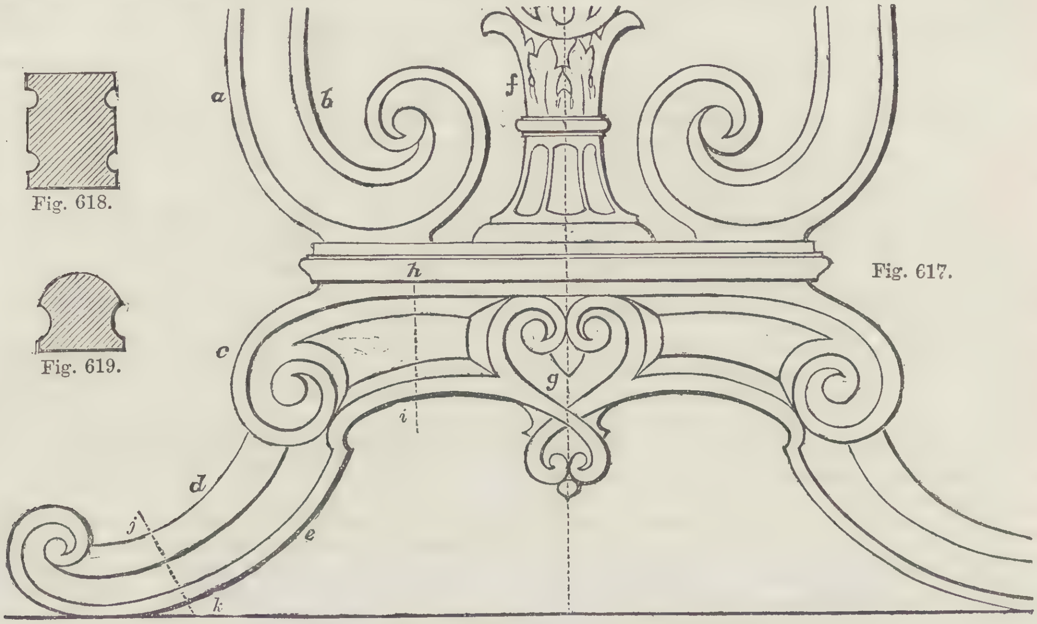


Fig. 618.

Fig. 619.

Fig. 617.

Now draw the scroll *a* on the left, and balance it by the corresponding curve on the right side; then draw the interior line *b*, but omit for the present the inner lines showing the edging. The drawing should, in fact, at this stage show the work as roughly cut out by the saw, before being handed over to the carver.

Draw the scroll *c*, and the curve *d*, for the outer line of the leg, repeating the same on the opposite side, and complete the general form of the legs by the interior outline *e*, which is to be carried round so as to form the scroll terminating the foot.

Next draw the middle part *f* of the upper portion of the subject, and the scrolls crossing each other in *g* beneath it. Having taken a careful survey of the whole, with the view of correcting the general form and proportion, the inner lines, showing the edging, etc., are to be drawn. Figs. 618 and 619 are sections on *h i* and *j k*, which will serve as guides in this portion of the work. The whole drawing will then be ready for "lining in."

Fig. 620.—This is a pattern for a running scroll, arranged so as to repeat; *a* will therefore join on at *b*, and thus the design may be continued.

It will be seen that, in order to equalise the spaces so as to carry out this arrangement, the whole is divided into squares, and the central flower is placed on the intersection of the diagonals.

In commencing this design, the general form is to be sketched of each scroll rising out of the previous one. At this stage no notice should be taken of the husks or foliage, *c*, *d*, etc., but the scrolls should be sketched as if consisting of the flowing stem only, and the husks should then be drawn outside the original form.

Great care must be exercised to ensure the smooth, spiral character of the curves. There must be no angular breaks, but the eye must be carried onward towards the centre of each scroll, and the husks must appear as *additions*, but not as *excrescences*. In order to test the correctness of the forms, turn the sketch upside down, place it vertically, or in any other direction, and if the design has been correctly sketched, the scrolls should be equally perfect in whatever position they may be viewed. This should be repeatedly done during the progress of the work, so that any part which may be too full or too flat may be improved before the husks, flowers, foliage, or other details are added.

Fig. 621.—The design shown in this example is a scroll such as might be used in ornamenting a console, etc. We shall give the description here with such hints and instruction as may be necessary to the learner, but the design itself will be found in our next lesson. (See Fig. 621, page 125.)

Draw the right angle in which the figure is to be contained, then sketch freely the spiral commencing at A, and continuing to B, following the direction of the stem only, regardless at the present stage of the foliage by which some portions of it are covered.

are then to be added. The separate portions of the leaves are next to be drawn within the forms already traced. The whole is then to be carefully corrected and lined in.

The student is urged to vary the studies herein given, to reverse them, and in every case to copy them of a different size.

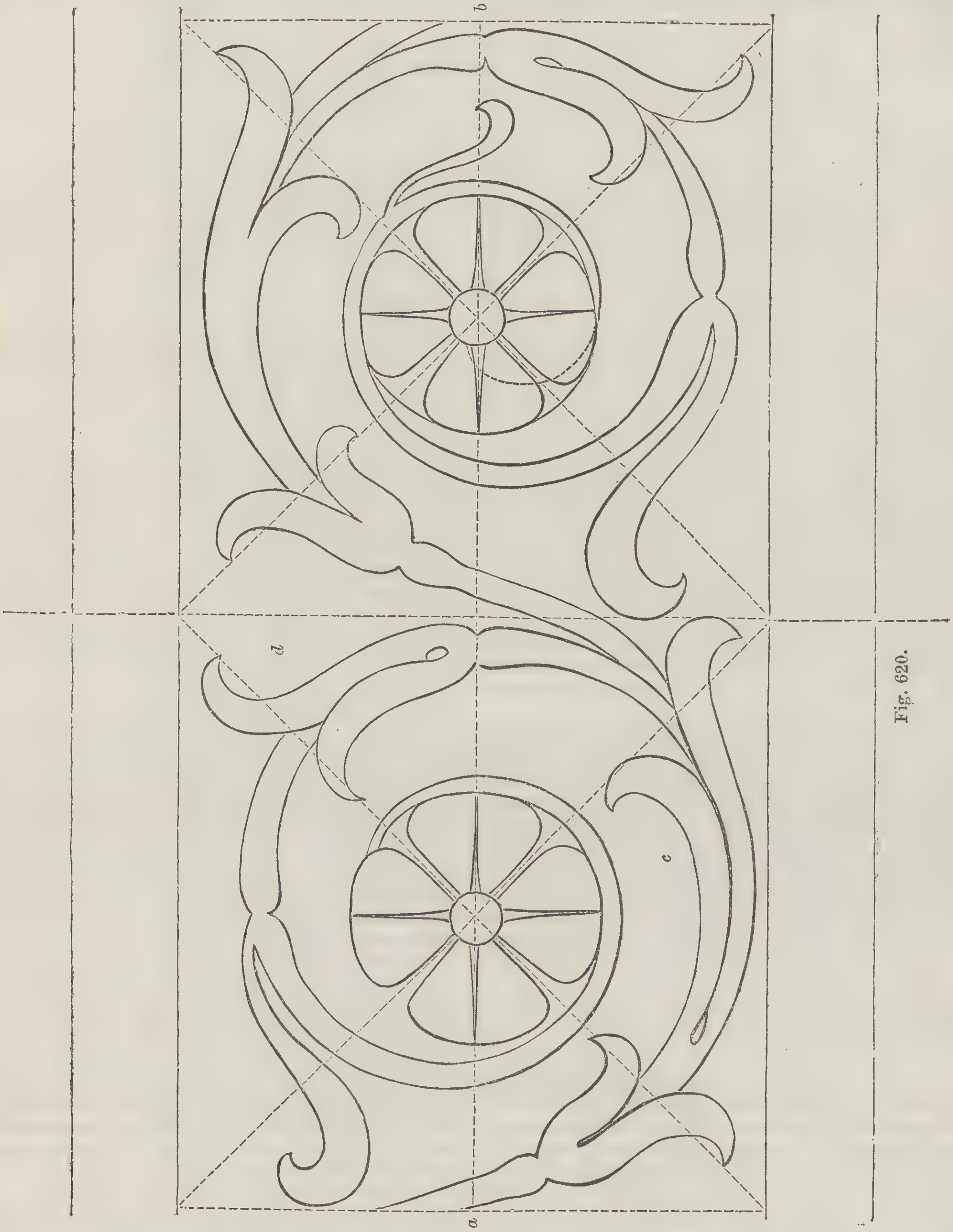


Fig. 620.

When this curve has been satisfactorily traced, draw the corresponding one, commencing at C, and following to D.

The foliage is next to be drawn, and in doing this the general form must be sketched first—the shape, as it were, of the block out of which it would be carved. This is shown in one portion, commencing at E. Thus from E draw the form extending to F, and thence to G. This will give the one lobe. Next proceed to H, and thence to I. In this way the whole of the foliage is to be sketched in, and the bud and minor parts Natural flowers and foliage afford the most excellent subjects for study, and thus the student who wishes to work need never stand still for want of examples.

We have said that the design to which the description just given applies is one which might be used in ornamenting a console or bracket. It will be a useful exercise for the student to attempt to make such a drawing as he may imagine to answer to our description, and then compare it with our design in Fig. 621 (page 125).

PATENTS AND PATENT LAW.—III.

By A Barrister.

HOW TO OBTAIN A PATENT AND HOW TO EXTEND IT.

We have seen what may be the subject of a patent, and who may obtain a grant of letters patent. The subject next requiring consideration is, how is the grant to be obtained? The principal matters requiring attention are the specification, the drawings, models, and specimens, the declaration of the inventor, the petition, the payment of the stamp duty, the letter patent, the examination of the letter by the Attorney-General, and his certificate.

First, then, as to the specification. The specification is either provisional or complete. The office and effect of the former is this. The Act of 1852 provides that any invention may be used and published for six months from the date of the application for letters patent for the invention, without prejudice to the letters patent, provided the provisional specification, which describes the nature of the invention, and is to accompany the petition for the letters patent, be allowed by the proper law officer (15 & 16 Vict., c. 83, s. 9). The same statute enacts that the applicant, instead of having a provisional specification, may, if he think fit, file a complete specification under his hand and seal, particularly describing and ascertaining the nature of his invention, and in what manner the same is to be performed, in which case the invention will be protected for six months from the date of the application, and may be used and published without prejudice to any letters patent to be granted for the same (sect. 9). A particular description of the invention is one of the conditions which we observed clog a patent. The specification must be clear and precise, in writing, under the hand and seal of the applicant, and it must be filed in the High Court of Chancery within a given period, generally six calendar months from the date. If a complete specification be filed along with the petition for the letters patent, then, in lieu of a condition for making void the letters patent in case the invention be not described and ascertained by a subsequent specification, the letters patent shall be conditioned to become void, if such complete specification does not particularly describe and ascertain the nature of the invention, and in what manner the same is to be performed.

The framing of the specification is a matter of great nicety. The description which it contains must correspond with the title of the invention contained in the letters patent; it must clearly describe the invention, but not go beyond the proper subject of the patent; nor must it omit anything necessary to make the description intelligible. The importance of being accurate will be plain when we state that whilst a patent has been held valid, the patentee has had its operation limited by reason of a defective specification. As an example, the title of a patent was "for the invention of certain improvements in the doors and sashes of carriages." The specification described the object of the patent in the following terms:—"I have shown my invention applies to railway carriage doors and window fittings, although the said several fittings are applicable to and may be applied to the doors and windows of any other description of carriage, or in any position where windows and doors are subject to jar or vibrate." It was decided that the words indicating that the invention might be applied to doors and windows other than those of carriages, did not amount to a claim that such additional applicability of the invention was comprised in the patent; for that the claim must be construed with reference to the title of the patent, and confined accordingly to the doors and windows of carriages.

Here we come upon one of the disadvantages under which patentees labour. Specifications are construed by the courts, and yet we have no court for the trial of patent causes. Mr. Justice Grove is the only judge on the bench who professes to understand patent law. Where novelty or infringement depends merely on the construction of the specification, it is a pure question of law for the judges; but where the consideration arises how far one machine, or a material part of one, imitates or resembles another in that which is the alleged invention, it generally becomes a mixed question of law and fact which must be left to the jury. The only aid which can be given to the court in construing a specification, is that obtainable by means of evidence admissible to explain terms of art or technical expressions known only to particular trades. There is a means, however, by which a grantee or assignee of any letters patent may abandon portions of the title or specification, and this process is called a disclaimer. This disclaimer must be entered with the clerk of the patents, after leave obtained, in the case of an English patent, of the Attorney-General or Solicitor-General, certified by his fiat and signature. The reason for the disclaimer must be stated. Or a memorandum may be entered, on leave being similarly obtained, setting forth any desired alteration in the title or specification —the disclaimer or alteration not being such as to extend the exclusive right granted by the letters patent—and such disclaimer or memorandum of alteration, being filed by the clerk of the patents, and enrolled with the specification, is to be deemed and taken to be part of such letters patent or specification in all courts whatever. The most obvious occasion for a disclaimer is where the Crown has been deceived, or if the specification is in any respect false or likely to mislead, so that the public cannot enjoy the benefit in the most ample manner. These are defects which must be cured. By the above process a patent originally bad may be made good from the time of the disclaimer or alteration.

We have mentioned the drawings and specimens. Where they are referred to in the specification they form part of it, and may help to make good a specification which would be otherwise defective. Next as to the declaration. The statute (5 & 6 Wm. IV., c. 62) says that whenever any person or persons shall seek to obtain any patent under the great seal for any discovery or invention, such person or persons shall make a declaration in the form of the old oath. The declaration states that the inventor has invented, and that he believes his invention will be of general benefit and advantage. Next we have to consider the petition which gives the title of the invention. This title must be very carefully framed, as will appear from a statement of two cases. Letters patent for a whole watch, the specification disclosing the invention of a particular movement only, were held void, on the ground of the title being more extensive than the invention. Letters patent were granted for an "improved method of lighting cities, towns, and villages," and the specification disclosed an improvement of the old street lamp, of parts known before, by a new combination. The letters patent were held void. But generality in the title, if not inconsistent with the invention as described in the specification, will not vitiate the letters patent. After the statement of the title in the petition, follows the averment, "which invention he believes will be of great public utility;" that he is the true and first inventor thereof, that the same is new in England, and that the same is not in use therein by any other person or persons, to the best of his knowledge and belief. The petition closes with a prayer that Her Majesty will be pleased to grant unto the inventor, his executors, administrators, and assigns, her royal letters patent under the great seal of Great Britain, for the sole use, benefit, and advantage of his said invention for the term of fourteen years.

This petition, with the declaration of the inventor, and provisional specification, must be left at the office of the Commissioners of Patents, who will refer them to the Attorney-General or Solicitor-General to consider. The law officer gives his certificate, and after some further forms and delays, the Lord Chancellor causes letters patent for the invention to be sealed with the great seal of the United Kingdom, granting to the applicant the exclusive right of using the invention within the United Kingdom, the Channel Islands, and the Isle of Man, and (if the warrant of the Patent Commissioners so direct) within the Colonies, for the full term of fourteen years. The letters patent always contain a proviso to the effect, that if the "complete specification" already filed does not particularly describe the nature of the invention, and in what way the same is to be used, or if none be filed, then if the applicant does not within a limited period file such a specification in the Court of Chancery, the grant in the letters patent contained shall be void.

A difficulty may arise in the course of these proceedings by the opposition of those interested in objecting to the grant of the letters patent. Any such persons are at liberty within a certain period to lodge particulars in writing of their objections. Similarly, objections may be made to applications to the Privy Council to prolong patents, a matter to which we will now

shortly advert, as being in effect a part of the grant. What the requirements of the Privy Council are, may best be explained by reference to the case of Hill's patent, a prolongation of which was opposed by a host of opponents. It was there said that in determining whether to recommend a prolongation of a patent or not, even where the claim to the first discovery and the beneficial nature of that discovery are both conceded, it will be still proper to consider both the degree of merit as inventor, and the amount of the benefit to the public flowing directly from the invention. These general observations, going really to the root of the principle upon which patents are granted, then follow:—A monopoly limited to a certain time is properly the reward which the law assigns to the patentee for the invention and disclosure to the public of his mode of proceeding. Whether that term shall be extended, in effect whether a second patent shall be granted for the same consideration, and the enjoyment by the public of its vested right be postponed, is to depend on the exercise of a discretion, judicial indeed, yet to be influenced by every such circumstance as would properly weigh on a sensible and considerate person in determining whether an extraordinary privilege not of strict right, but rather of equitable reward, should be conferred.

The prolongation of the patent in Hill's case—for an improved mode of compressing peat for making fuel or gas, and of manufacturing gas, or of obtaining certain substances applicable for purifying the same—was opposed on the several grounds of want of novelty, want of utility, and of the patentee having had sufficient remuneration. The Judicial Committee refused to entertain the objections going to the root of the validity of the patent—viz., want of novelty and want of utility—but proceeded to the question of want of merit in the inventor. The crucial test applied by this court was, has the individual patentee, under all the circumstances, received what in equity and good sense may be considered sufficient remuneration? To assist the court, a patentee on applying for a prolongation must furnish accounts, and it may be well that we should take from the judgment in Hill's case a description of the accounts required. "It must be remembered," are the words of the judgment, "that the accounts which a patentee renders in support of such a petition as the present are not such as might be proper between two several claimants on the returns of a mercantile firm, but such as show what profits made by a firm or individual are in a large sense attributable to the possession of the patent right—those which, without the patent, would not have existed at all; not, of course, excluding all just deductions for labour, capital, etc. If, but for the patent, there would have been no manufactory, then the net profits of the manufacturer are in that large sense attributable to the patent. . . . . Their lordships cannot satisfactorily discharge their duty unless they have the whole case before them. They must know the whole remuneration; different considerations may be applicable to different parts of it; but if to any extent the patentee has received his remuneration by the making and selling the patented article, the profits on that sale must be disclosed and taken into account." As to the deductions allowable, a patentee is not entitled to deduct from profits any loss by foolish or imprudent bargains, or hasty compromises of litigation; and where he manufactures his own invention, he is not entitled to deduct two-thirds as manufacturers' profits, and count only the other third as the profit alone attributable to the patent.

The prolongation of patents, we have before remarked, is entirely discretionary, and any reasonable conditions may be imposed. For example, in the case of Mallet's patent relating to the construction of fire-proof structures, licences had been granted by the patentee, and the Privy Council prolonged the term on condition that similar licences were granted to the public on the same terms.

It may be advisable to advert briefly to a case in which a patentee was held to have deprived himself of all right to a prolongation. This was the case of Trotman's patent for improvements in anchors, and in addition to the fact that his accounts were unsatisfactory, the Judicial Committee of the Privy Council considered that he had so dealt with his patent rights as to deprive himself of the power of showing the amount of profit derived from the working of the patent. This was the essential element, as the prolongation was asked for on the ground that the patentee had been insufficiently remunerated. This question of insufficient remuneration being an important one, we will quote the observations of Lord Chelmsford. There was, he pointed out, a peculiarity in this case—viz., the patentee, "instead of becoming himself a manufacturer of his patented anchors, has preferred to grant licences to ironsmiths to manufacture them on their own account, paying him a royalty. In all prior applications for the extension of the term of a patent, the patentee has himself made and sold the patented article, either exclusively or in common with other persons to whom he has granted licences, or he has assigned away his patent altogether, so as to substitute his assignee for himself in all questions respecting his patent rights. In these cases there is obviously no difficulty in ascertaining the profit which has been derived from the patent. It is supposed, however, that the unusual manner of working the patent in this case renders the application of a different principle necessary. This, however, is clearly a misapprehension. The question in all cases of this description is not what the patentee has received, but what has been made, or by proper judgment and application might have been made, by the patent. The petitioner might, if he pleased, have become the manufacturer of his patented anchor. If he had, it would have been necessary to ascertain what part of the profits of the manufacturing business ought to be ascribed to the patent. . . . But the petitioner was unwilling to incur a large expenditure in erecting the proper plant for carrying on the manufacture, and preferred to leave the expense of the new machinery necessary for forging his anchors to the licensees, being content to receive a royalty as his share of the profits of the patent business. Under these circumstances, if his royalty alone were to be regarded, it is evident that we should not arrive at a knowledge of the whole amount realised by the patent, but that the question would be changed from what the patent had produced to what it had yielded to the patentee." And on the general principle of prolongation it was said, "It must always be borne in mind that the extension of the term of a patent is matter of favour, not of right; and that it is essential to the favourable consideration of the patentee's application, that he should distinctly prove how much the public have had to pay, or, in other words, how much has been received on account of the patent. If, therefore, the patentee has dealt with his patent rights in such a manner that, when the time arrives for asking for a renewal of his term, he has put it out of his power to give the requisite evidence upon which his application must to a great extent have been founded, his petition must fail, because it wants the proof which is essential to its success." From this we deduce that a patentee who is his own manufacturer is in the best possible position for obtaining the renewal of his term.

Patents taken out in a foreign country may have an important bearing upon the question of prolonging English patents. The rules under the Act of 1852 seem to be these:—If an English patent is taken out before a foreign patent, the prolongation of the English patent will be granted, although the foreign patent has expired. Where a patent is taken out in a foreign country before a patent for the same invention in the United Kingdom, the latter patent must terminate at the same time as the foreign patent. And where the term of a foreign patent has expired, any grant of letters patent in the United Kingdom made after that period is of no validity. And where the two patents are taken out simultaneously, it would seem that a prolongation of the English patent may be granted.

Lastly, as incidental to obtaining a patent, we may refer to the payments to be made by the patentee. The statute 16 & 17 Vict., c. 5, s. 2, provides for the payment of the stamp duties set out in the schedule at the expiration of three and seven years from the granting of the patent. Unless these payments are made the letters patent will be void, and the powers and privileges thereby granted will cease. It may be interesting to our readers to know what these payments are. The schedule contains the following:—On petition for grant of letters patent, £5; on certificate of record of notice to proceed, £5; on warrant of law officer for letters patent, £5; on the sealing of letters patent, £5; on specification, £5; on the letters patent, or a duplicate thereof, before the expiration of the third year, £50; on the letters patent, or a duplicate thereof, before the expiration of the seventh year, £100. An application for a disclaimer costs £5.

INDIAN RUBBER.—I.

BY GEORGE GLADSTONE, F.C.S.

FIRST INTRODUCTION — SOUTH AMERICAN CAOUTCHOUC — INDIAN CAOUTCHOUC — SIPHONIA ELASTICA — MODE OF COLLECTION — FICUS ELASTICA — URCEOLA ELASTICA — CHEMICAL CONSTITUTION — PHYSICAL PROPERTIES.

It is only since the beginning of the last century that indian-rubber or caoutchouc has been known in this country; and when the first specimens arrived, speculations were rife as to whether it belonged to the vegetable or mineral kingdom. This may seem now to be very absurd; but there were stronger reasons for inferring a mineral origin than perhaps even those who held this view were aware of at the time; this will more particularly appear when we come to speak of its chemical composition. The question as to its vegetable origin was set at rest by a communication to the French Academy in 1736, in which it was stated to be the inspissated juice of a tree which grows in South America.

From that time till 1770 it appears to have been a mere curiosity. In that year it was introduced to the British public for the purpose to which it was long almost exclusively devoted, and from which it has derived its familiar name. In the preface to a book on perspective published in that year, the following singular passage occurs. "Since this work was printed off, I have seen a substance (no name is given to it) excellently adapted to the purpose of wiping from paper the marks of a black-lead pencil. It must, therefore, be of singular use to those who practise drawing. It is sold by Mr. Nairne, mathematical instrument maker, opposite the Royal Exchange. He sells a cubical piece of about half an inch for three shillings, and he says it will last for several years."

Just fifty years after that time experimenters, attracted by its singular and valuable properties, began to turn it to new and more important uses; and in 1823, Mr. Mackintosh, of Glasgow, succeeded in applying a solution of Indian rubber to cloths, by which he made the waterproof article which has since borne his name.

Up to that period the supply of the raw article was almost exclusively limited to South America, although some identical in its properties was known to be procurable in India, having been discovered by Dr. Roxburgh in Assam about fourteen years previously. Had it not been for the exertions of Dr. Forbes Royle, the East Indian caoutchouc might have remained much longer in obscurity; for when a gentleman up the country sent some to his agents in Calcutta, they simply wrote in reply that "the article being unknown in this market, we are sorry we can give you no idea of its value." This happened in 1828, when it was selling in London for 2s. per lb. By 1840 it had become a regular article of export, and by its competition had considerably reduced the price of the South American caoutchouc. From this time onward the sources of supply have been increasing as new modes of utilising it have arisen; and it is satisfactory to know that with proper care the produce of Indian rubber may be considered practically inexhaustible.

It is not a little curious that what is generally known as the Indian rubber tree, young plants of which are grown so largely in London rooms, is not the one which was first discovered, or which even now supplies the great bulk of the raw material. It is the Assam plant; whereas the South American one belongs to an altogether different family.

Fig. 1.—SIPHONIA ELASTICA.

The Euphorbiaceæ, or family of Spurgeworts, which are common in all the four quarters of the globe, all produce a milky juice, and it is this which in drying yields caoutchouc. *Siphonia elastica* is the tree from which it was originally derived. It grows in the low lands which form the basin of the great river Amazon. It is a true forest tree, growing up to a great height, generally 40 to 50 feet, before throwing off any branches; and sometimes reaching 80 to 100 feet in all. The trunk is usually 2 to 2½ feet in diameter. The crown is spreading and ornamented with a thick and glossy foliage, the character of which may be judged of by the accompanying drawing (Fig. 1). The milk may be collected at any period of the year, but it is considered best to do so in the dry season; and as the trees which have hitherto been tapped are those growing on the islands and in the swamps within the distance of 50 to 100 miles to the east of Para, there is an additional cause for choosing the dry season. This lasts from August to February. The trees, however, are not confined to this limited area; for Mr. Bates, on exploring the Amazon and its tributaries, found plenty of untapped trees in the wilds of the Tapajos, Madeira, Juruá, and Jauarí, as far inland as 1,800 miles from the coast.

The rubber—the original native name for which is *cahuchu*—

is collected in the following manner:—As soon as the dry season has set in, a party of Indians, men and women, proceed into the virgin forest to seek a clump of Siphonia trees, and when they have found a suitable sphere of operations, they cut paths through the wood to it. This is a work of no little difficulty, as, owing to the fertility of the soil and the tropical climate, the undergrowth forms a dense mass, and every step must be gained by the axe. Having effected a clearance, they make an incision in the trunk of each tree, about five or six feet above the ground, just below which they stick rude cups of clay to receive the milk as it flows out. Each morning they make a round of the trees to empty the cups of the milk, usually about a gill in quantity; and when the first incision ceases to yield, a second, and then in like manner a third and a fourth, is made. By this time the tree is exhausted, and it will not recover itself for a couple of years. The milk collected day by day is poured into larger vessels, and then the manufacturing of the rubber commences. For this purpose the natives gather together in heaps a quantity of Urucari or Inaja nuts, which, upon being set on fire, yield a thick oily smoke. Moulds of clay, in the shape of shoes, bottles, etc. etc., are prepared, which are dipped into the milk, and then held over the fire to dry. This is repeated day by day, until the articles have acquired sufficient thickness. The juice itself is yellowish, and of the consistence of thick cream, the dark colour of the manufactured article being due solely to the smoke in which it is dried. In some interior districts, where the nuts are not found, the rubber is sun-dried, and of a very light colour. For some little time after the smoking is finished the surface is rather sticky, and the several pieces would be liable to adhere together if they were allowed to touch; the shoes and other articles are therefore hung over horizontal poles to dry, and the natives usually bring their produce to market suspended in the same manner.

Several other kinds of Siphonia are to be found in tropical Brazil and Guiana, as well as other members of the family of Euphorbiaceæ, which also yield caoutchouc, but not in such quantity as the one above described.

The *Ficus elastica*—commonly known here as the Indian-rubber tree, from the diminutive specimens in rooms and greenhouses—belongs to the large family of Artocarpaceæ, which includes the Banyan, *Ficus Indica*—the largest of known trees—and the Breadfruit, which is the most prolific. The tree is found in great abundance in the forests of Assam and its neighbourhood; it is a true forest tree, of rapid growth, attaining 80 to 100 feet in height, with its branches extending to the distance of 75 feet in all directions from the parent stem. The larger branches throw out roots which descend to the earth, in the same way that the Banyan does. The incisions for the drawing off of the juice are made in the bark around the trunk, beginning at the base, or at the reflex roots, which generally lie exposed. The juice from the roots is found to be richest in caoutchouc. The oldest trees should be selected for the purpose of tapping, and the operation conducted in the cold season, as the juice then contains the largest proportion of solid, and the health of the tree is less affected than it would be were the sap withdrawn during the period of rapid growth. The bleeding may be repeated every fortnight; about 45 lbs. weight being obtained on each occasion. In India the rubber is sun-dried, so that it retains its light colour. The tree is generally to be found in the sheltered nooks of a rocky district; and as the region in which it is indigenous has as yet been only imperfectly explored, there are no precise data for estimating the probable supply from this tree. Sufficient, however, is known to assure an abundance of it for a long time to come. Other sorts of Ficus—the *Indica* and *religiosa*—also yield caoutchouc; and so does the Jack Tree, or *Artocarpus integrifolia*; but these are not usually tapped for the purpose.

Again, in the southern part of the Malay Peninsula, and in the great islands of Sumatra and Java, there is the *Urceola elastica*, belonging to the order Apocynaceæ, which yields the same product in great abundance. This plant, indeed, was the principal source of supply from the East prior to the introduction of that from the *Ficus elastica*. Its importance seems to have been discovered by accident, towards the close of the last century, the circumstance being recorded in the "Asiatic Researches" of 1798. It appears from the narrative, that in clearing a way through the jungle with cutlasses in the island of Penang, the juice which had collected on the blades turned on drying into a substance possessing all the characteristics of Indian rubber. The source of the juice was found to be a vine about as thick as a man's arm, which trailed along the ground for a great distance, sending out rootlets from each joint, and ultimately climbing to the top of the highest trees. Fig. 2 will show the character of its foliage.

Fig. 2.—URCEOLA ELASTICA.

These three plants which have been more particularly described are by far the most important that are yet known. But the families to which they belong are so widely spread, that there is every reason to expect that as the tropical regions both of the Old and New World are more thoroughly explored, many other districts will be added to the list of those which now produce this article. Its production seems to be greatly favoured by heat, as the milky juices of the Euphorbiaceæ which grow in temperate climates contain next to none of the solid matter; and it has been remarked by Humboldt that the proportion of it increases as the region from which they are derived is more essentially tropical.

The quantity of Indian rubber contained in the juice varies greatly, up to about 45 per cent. The rest consists almost exclusively of water, which is artificially expelled in South America, and by exposure to the heat of the sun in India. The

season of the year, the age of the tree, and other circumstances, all have their influence in increasing or decreasing the proportion of caoutchouc in the sap.

Caoutchouc is, in chemical language, a hydrocarbon; that is, a substance consisting of only the two elements, hydrogen and carbon. It would perhaps be more correct, however, to use the plural number, as it does not appear to consist necessarily of one, but rather of two or more hydrocarbons mingled together. The analysis by Faraday of a carefully selected sample gave the respective proportions at 87·2 per cent. of carbon, and 12·8 per cent. of hydrogen, which would indicate a composition of C_4H_7, or a multiple of those numbers. Other experimenters, however, have obtained results rather different from his, which points to the conclusion that it is not a strictly definite substance; and this is confirmed by experiment, for on dissolving it, one portion is often found to be more soluble than another, and the resulting solution cannot all be distilled over at a uniform boiling-point.

Under the microscope there is no evidence in Indian rubber of any structure, either fibrous or cellular, which would serve to identify it as of vegetable origin; and those who formerly declared it to belong to the mineral kingdom might have produced in support of their view an undoubtedly fossil hydrocarbon, also possessed in some measure of elasticity. Now-a-days, too, it is from the bowels of the earth that we derive the raw article from which by far the greater portion of our hydrocarbons are manufactured.

These, indeed, are common enough; but this one, prepared in Nature's laboratory, enjoys properties peculiar to itself, which render it specially interesting, and of the greatest importance in the arts. It will be as well to run over these cursorily at first, as they will call for fuller detail, when speaking of its manufacture and applications.

1. *Lightness.*—The specific gravity of the rubber made from the *Ficus elastica* is about 0·92, and of that from the Siphonia 0·94.

2. *Elasticity.*—In this respect it stands almost without a rival. After being softened by immersion in warm water, it can be drawn out to about eight times its natural length, to which it will return again on the tensile force being withdrawn. Its elasticity, moreover, can be suspended, and restored again at pleasure.

3. *Resistance to Pressure.*—This is the converse of the preceding. Whatever the compressive force that may be applied, the Indian rubber will recover its original bulk on the pressure being withdrawn.

4. *Insolubility in, and Imperviousness to Water.*—These qualities, coupled with the fact already mentioned of its being lighter than water, suggest at once a multitude of applications, if only the difficulties of manipulation are surmounted. How that is done will be seen presently.

5. *Resistance to the Action of Alcohols, Acids, and Alkalies.*—These qualities are of especial value to the experimental and manufacturing chemist.

6. *Resistance to Atmospheric Influences.*—The only important exception seems to be in respect to exposure to sunlight. In this case an oxidation of the substance takes place, which changes its character altogether; but the action only takes place if the rubber is kept perfectly dry.

7. *Non-conduction of Electricity.*—This is a circumstance of no little importance in connection with one of the most important developments of modern science, the submarine telegraph.

NOTABLE INVENTIONS AND INVENTORS.

XXXIII.—CHLOROFORM.

BY JOHN TIMBS.

THE employment of *anæsthetics*, or substances for producing temporary insensibility to pain, had been known and practised for ages before it was discovered that by the use of chloroform pain might be put completely under the dominion of the human will. *Anæsthesia*, as such agency is termed, was known 1,800 years ago, when the Greeks and Romans used the root of the mandrake "to cause insensibility to pain in those who are to be cut or cauterised; for, being thrown into a deep sleep, they do not perceive pain." Pliny tells us that the juice of mandragora had a narcotic effect as a remedy for injuries inflicted by serpents, and before incisions were made in the body, in order to ensure insensibility to pain. "Indeed," he adds, "for this last purpose, with some persons, the odour of it is quite sufficient to induce sleep." "Again, by drinking mandrakes with wine," says Apuleius, "a limb may be cut off without any sense of pain." All narcotic medicines will produce conditions of anæsthesia in which surgical operations may be performed without pain; and during the operation of alcohol on the nervous system in drunkenness, operations have been performed without the knowledge of the patient.

It has been discovered by M. Stanislaus Jullien that the Chinese, in the third century of our era, employed an anæsthetic agent, in the same manner as we use chloroform and ether, for producing insensibility during surgical operations. It is stated that Hoa-tho, who flourished between the years 220 and 230 of our era, gave to the sick a preparation of chanvre (*ma-yo*), when, in a few moments, the patient became as insensible as one plunged in drunkenness, or deprived of life; then, according to the case, he made incisions, amputations, etc. After a certain number of days the patient found himself re-established, without having experienced during the operation the slightest pain. This *chanvre* is prepared by boiling and distillation, and is set down as the Indian hemp, which is taken even now by the Arabs to produce agreeable intoxication. Theodoric, a surgeon in the latter half of the thirteenth century, in his work on surgery, mentions "a flavour for performing surgical operations," made of "opium, mulberry, henbane, hemlock, mandrake, wood-ivy, and lettuce, to be boiled until concentrated in a sponge, which, when wanted, was to be warmed, and applied to the nostrils of him who is to be operated on, until he has fallen asleep; and so let the surgery be performed." In 1579 Bulleyn described "the possibility of setting patients into an anæsthetic state during lithotomy, etc.," by the use of mandrake.

The narcotic and anæsthetic properties of Indian hemp were known to the Scythians, who inhaled the fumes of hemp-seed thrown upon red-hot stones; and Indian hemp has been set down as the *Nepenthes* of Homer, which was brought from Egyptian Thebes. Bang, which is prepared from Indian hemp grown in Africa, is taken by criminals who are condemned to suffer amputation; and Sir Joseph Banks testifies to this use of it. This hemp is smoked in Congo, Angola, and South Africa; its leaves, seeds, and flowers are pounded and mixed with a confection, a piece of which, the size of a walnut, when eaten, will deprive a man of reason, and is described as "the increaser of pleasure."

Towards the close of the last century, Lassard, a surgeon of Paris, recommended the employment of a narcotic previous to serious and painful operations; and in a work by Meissner, in 1782, it is stated that Augustus, King of Poland, was surreptitiously narcotised by his favourite surgeon, Weiss, while a part of his foot, which had mortified after being wounded, was cut off without pain or consciousness. Shakspeare, in "Cymbeline," describes the imagined effects of subtle distilled potions, producing, without danger, a prolonged state of death-like sleep or lethargy.

The history of the various anæsthetic agents is interesting; but it was only by the science of chemistry that the seekers after a perfect anæsthetic agent were guided in the true direction; and it was ascertained that by means of the inhalation of various kinds of gases many maladies would become amenable to the power of the physician. In 1799 Humphry Davy breathed nitrous oxide, which he found to lessen the pain of cutting a wisdom-tooth; and although he did not succeed in establishing nitrous oxide as a medicinal agent, in describing the effects of this gas he predicted that, "as nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may, probably, be used with advantage during surgical operations in which no great effusion of blood takes place." Nor was this an accidental conception of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea which has become one of the most glorious realities of the present century. Davy also foretold that pneumatic chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded, "it is probable that pain would have been put into subjection to the intellect at the very beginning of the present century."

Forty-four years had, however, to elapse after Davy's

announcement that, "as nitrous oxide seems capable of destroying physical pain, it may probably be used with advantage during surgical operations," before this pregnant suggestion was acted on. In 1818, an article believed to have been written by Mr. Faraday, and published in the *Quarterly Journal of Science*, describes the great resemblance between the effects of the vapour of ether and those of nitrous oxide gas. In 1844, Horace Wells, a surgeon-dentist of Hartford, Connecticut, United States, having inhaled the gas, another dentist, Dr. Rigg, drew one of his teeth without pain, and Mr. Wells, after recovering from the inhalation, exclaimed, "A new era in tooth-drawing!" He then made other experiments, with various success; but a failure so annoyed him, that he became unsettled, came to England, returned to America, and at length died by his own hand, in January, 1848. Within three months Dr. Bigelow, of Boston, United States, removed a breast from a patient who had been rendered insensible by inhaling nitrous oxide. Next, Morton, Wells's pupil and partner, and Dr. Jackson, took up the idea, and having discovered that ether was much preferable for this purpose to nitrous oxide, they made known the important fact that under the influence of this agent insensibility might be produced under which persons might undergo the most severe operations without pain, and might be restored from this condition without injury to their health. On September 30, 1846, by the inhalation of ether Morton made himself unconscious during eight minutes; he also persuaded a patient to inhale ether from a handkerchief, and then extracted a bicuspid tooth, of which the patient knew nothing till he recovered his senses. The remedy was afterwards frequently used. Notwithstanding this success, the American medical journals condemned the discovery as a quackery, confirming the proverb, that "a prophet hath no honour in his own country;" the English journals, however, at once rightly appreciated it, though in November, 1846, the Paris surgeons received the announcement with all but indifference. Velpeau politely declined even to test its worth; yet, in January, 1847, the two great surgeons, Velpeau and Roux, averred, in the presence of the two Academies, that the discovery was "a glorious conquest for humanity."

In London the action of this new agent was extensively tried, and rightly appreciated. In January, 1847, the first experiment was made in England by employing the inhalation of sulphuric ether as a means of rendering surgical operations painless. The application had been communicated by Morton to Dr. Boott, of No. 24, Gower Street, who described it to Mr. Robertson, the surgeon-dentist, also of Gower Street. This gentleman, on the following day, operated upon a lady thrown into sleep by the inhalation, during which a molar tooth was extracted from her lower jaw. The inhalation occupied a minute and a half, and the patient's recovery from sleep another minute. Dr. Boott questioned her respecting the tooth, and she expressed her great surprise at finding that it was removed. She said that all she felt was merely a sensation of cold around the tooth, a sensation which was caused, perhaps, by the coldness of the extracting instrument. The apparatus employed consisted of the lower part of Nooth's apparatus, with a flexible appendage, to which was attached a ball-and-socket valve and mouth-piece, similar to those commonly employed for inhalation, together with a nasal spring. The full effect of the vapour was produced in from one to two, or three minutes generally, and as soon as it was perceived, the operation was performed.

Among the early cases recorded is that Mr. Liston, of University College Hospital, on December 21st, "amputated a thigh, and removed, *by evulsion, both sides* of the great toe-nail, without the patient being aware of what was doing, so far as regards pain;" he heard what was said, and was conscious, but felt neither the pain of the incisions, nor that of tying the vessels. Next, a patient in the Royal Infirmary, Edinburgh, was etherised, and had a limb amputated by Dr. Duncan, "without the infliction of any pain."

"Alas! that we must close this brief history of the discovery and application of the anæsthetic properties of ether, by stating that Morton shared the fate of almost every discoverer, viz., poverty, and the danger of being deprived of the honour of the discovery. The excitement of it injured his health. Having taken out a patent for it, and hoping, doubtless, that it would make his fortune, he neglected his business. Jackson, although he was content to get only a third share of the patent, claimed the whole merit of the discovery in a paper which he sent to the French Academy, and in which he suppressed Morton's name. Chloroform quickly superseded ether, and Morton found his patent valueless, his business destroyed, and even the bare honour of the invention wrested from him. But the pain with which we think of his misfortunes is greatly lessened by the knowledge of his attempt to keep his discovery a secret, and, under the name of 'Letheon,' to secure the possible profits of it exclusively for himself, by means of a patent, contrary to the usages of the profession." (Dr. Chapman, *Westminster Review*, 1859.)

A month after the first application of ether in England, Dr. Simpson, of Edinburgh, discovered that by its instrumentality the ordinary pains of maternity might be averted without danger. The remedy was used also, with a greater or less degree, in some of the most fearful and painful diseases; and by its aid many persons were rescued from certain death who must otherwise have undergone a difficult and most painful operation.

Ether, the first agent employed in this great revolution, is said to have been known to Raymond Lully and Basil Valentine the alchemists. In 1540 Valerius Cordus described the method of making it—the *oleum vitrioli dulce*, as he termed it. It consists of 4 atoms of carbon, 5 of hydrogen, and 1 of oxygen. It is usually procured by distilling common alcohol (the hydrated oxide of ethyle) with sulphuric acid; hence its usual name of sulphuric ether; its present chemical name is oxide of ethyle. "Ether," says Dr. Frobenius, "is certainly the most noble, efficacious, and merciful instrument in all chemistry and pharmacy, inasmuch as essences and essential oils are extracted by it immediately, without so much as the mediation of fire, from woods, barks, roots, herbs, flowers, berries, seeds, etc., from animals, and their parts, too."

The mixture, improperly called chloric ether, which is simply a solution of chloroform in alcohol, was, early in 1847, demonstrated by Mr. Jacob Bell to possess anæsthetic power. He exhibited its effects at St. Bartholomew's and Middlesex Hospitals. Mr. Waldie, of the Apothecaries' Hall of Liverpool, first acquainted Professor Simpson with the properties of chloric ether, which was mentioned during conversation, and Mr. Waldie being well acquainted with its composition, and with the volatility, agreeable flavour, and medicinal properties of chloroform, recommended the professor to try it. Acting on his advice, Dr. Simpson procured chloroform, undiluted, discovered the effects of its vapour, and thus bound his name indissolubly with one of the greatest boons ever conferred on man.

FARMING AND FARMING ECONOMY.

XVII.—FATTING CATTLE.

By Professor Wrightson, Royal Agricultural College, Cirencester.

Cattle may be fattened at any age. Calves, yearlings, and two-year-olds have all been made ready for the butcher, but the usual and best plan is to delay the process until the animal has arrived at something like maturity. This, owing to the improvement which has been effected by breeders of stock, takes place much sooner than was formerly the case, and at two-and-a-half years old steers commonly find their way into the fatting stalls.

In the management of fatting cattle care must be taken that the animals are quiet and comfortable, and that they are regularly supplied with sufficient quantities of suitable food and water. Each of these points is important, and we are therefore led to inquire, how cattle are best made comfortable? What is a sufficient supply of food? What foods are most suitable for fatting stock? and afterwards we shall discuss the questions of cost and return.

ACCOMMODATION FOR FATTING CATTLE.

Cattle are fed in fold-yards, boxes, and stalls, or byres. As we intend on a future occasion to devote a chapter to the subject of farm buildings, we defer the consideration of the structure and dimensions of these several kinds of accommodation. Small, well-shedded and spouted (troughed) fold-yards, protected from the north and east, give excellent shelter; but, owing to their being open and exposed to rain, they require a

large quantity of straw to be used as litter. The manure made in fold-yards suffers in quality from this reason.

The *box* system provides a separate apartment for each animal, and the boxes being arranged in a continuous series, the cattle have the advantages of society without any of its annoyances. Heifers, being apt to fight with each other, are the better for this restraint. Boxes, besides the above advantages, necessitate a smaller amount of straw as litter, and ensure a high quality of manure, owing to the protection they afford from rain.

The *byre* is almost universally employed for milch-cows, and is also used for fatting cattle. Tying up animals for long periods of time, as in the case of fatting cattle, is however unnatural, and unless the curry-comb and brush are freely used, they soon become dirty in the coat, the hair falls off in patches, and the skin becomes irritable. The hoofs of cattle so confined also grow to such an extent as to be impediments to the progress of the unfortunate animal, when at length he has to be driven to the shambles. These evils may with proper care be avoided, and this being granted, the byre possesses solid advantages. Where space is an object, no system of housing will accommodate so large a number of cattle in a given area, and it is the most economical method with regard to straw. The manure is, however, not well mixed, owing to the constrained position of the animals, and for this reason the litter ought to be daily removed, and spread evenly over a fold-yard, there to be further trodden down by young stock, and turned over by pigs. Whatever system is adopted, it is essential that the animal should have a comfortable bed, be protected from cold winds, supplied with water, and kept quiet.

FOOD AND FEEDING.

The selection of suitable foods and the best methods of giving them are the most important considerations in feeding cattle. We do not propose to study the chemistry of foods, but rather to adhere to a simple statement of the best agricultural practice. Accordingly, we find a few well-known vegetables and vegetable products employed for this purpose, among which we may name the following:—Turnips, swedes, mangel, hay, straw, grass, clover, vetches, and other root and forage crops; also linseed, cotton, rape, and poppy seed cakes; barley, bean, and pea meal; lentils, locust beans, Indian corn, buckwheat, millet, and many other similar substances which, from time to time, are brought before the attention of farmers. There are also artificially prepared cattle foods, such as Thorley's, Beache's, and Simpson's, which may be used with advantage as condiments in exceptional cases, but are too expensive for general purposes. Of these feeding materials, the first few mentioned are those most generally employed.

Cattle-feeding is carried out upon the most simple principles in the north of England and Scotland. There, an abundant crop of swedes may be generally obtained, and these of higher quality than the roots grown in the south. Comparing north and south country practice, we have in the former case heavy root-crops of superior quality, and in the latter case precarious and light root-crops of inferior quality. This alone must make a great difference in the practice of cattle-feeding, and hence we find that while in the north the staple foods are turnips and straw, supplemented at the later stages by comparatively small quantities of cake and meal, in the south of England the amount of roots is lessened, while that of the "artificial" or dry foods is very much increased. Appliances such as the chaff-cutter, the root-pulper, and apparatus for cooking food, have also found more favour in the south than in the north. Were we to describe cattle-feeding as carried on north of the Tyne, our task would be sufficiently simple. There, fresh or "forward" beasts are placed in folds or boxes, supplied with a liberal allowance of turnips and straw, and as they approach fatness, with from 3 to 7 lbs. of linseed cake or a "crowdy" of meal. In the summer of 1866, the writer visited some of the best farmers in Berwickshire and Lothian. At Edington Mains, Mr. Wilson's cooking apparatus had not been used for the last year or two, and a general impression seemed to exist that the old method of turnips and straw, supplemented with from 5 to 7 lbs. of cake or corn, was after all the most successful plan. One great object of cattle-feeding in Berwickshire is to crush down straw into manure; and to this end, it is extremely common in good homesteads to find the yards unspouted, so that the rain-water may do its part in turning the straw into manure. "Mr. Lyal's (Green Knowe, Gordon) method of feeding cattle is simply turnips and straw, both given whole, and supplemented by moderate quantities, 5 to 7 lbs., of oilcake. The fold-yards are also kept unspouted, so that the rain-water may help the crushing of the straw into manure." (*Agricultural Gazette*, Aug. 27, 1866.)

Mr. Wilson, of Edington Mains, tells us in his "British Farming," 1862, that "important changes have now been introduced," but the day is still distant when the pulper, the chaff-cutter, and other improvements will become general. The plan pursued in the south may be illustrated by the practice followed on the College Farm, Cirencester (1866), where the cattle are placed in boxes, and receive a liberal allowance of cake and corn, chopped straw, a little hay, and a very small allowance of roots. From 50 to 100 lbs. of roots may be reasonably given to a fatting bullock, but in the case just cited they generally only receive 20 lbs.—a smaller quantity than we have ever known given, except in cases in which cattle are fed without roots. The amount of food varies with the weight and condition of the bullock, and is gradually increased towards the end of the fatting period as follows:—The cattle commence in October with 5 lbs. of meal, 2 lbs. of cake, 20 lbs. of roots, chaff, and a little hay. In November the food is changed to 7 lbs. of meal, 2 lbs. of cake, and roots, chaff, and hay as before. In January the food is again changed to 9 lbs. of meal, 2 lbs. of cake, 1 lb. of "cattle food," roots, etc., as before. This is continued until the termination of the fatting process. The food should be given regularly, and often. Thus on the College Farm the cattle are fed seven times a day:—

At 5.30 to 6 a.m., meal, chaff, and a few turnips (just to moisten the chaff).
At 7.30 to 8 a.m., 20 lbs. of sliced roots.
„ 9.30 a.m., meal and chaff.
„ 12.0 a.m., oilcake and chaff.
„ 2.0 p.m., meal and chaff as before.
„ 4.30 p.m., ditto, ditto.
„ 6.0 p.m., 4 lbs. of hay.

The quantity of meal and cake will vary as above, but it is divided pretty equally—the 4.30 meal being, if anything, the heaviest.

In a prize essay contributed by Mr. Dobito to the sixth volume of the *Royal Agricultural Society's Journal*, a very good system of cattle-feeding is explained. Mr. Dobito commenced with tankard white turnips, and 7 lbs. of pollards per day. Early in November the following system was practised:—The first thing in the morning the cattle received 1 bushel of swedes, cut small in a Gardner's sheep turnip-cutter. When these were eaten, the troughs were cleaned out, and the animals then received 2 lbs. of oilcake, 3 lbs. of pollards, and a little hay chaff. While eating this the litter was removed, the floor made clean, and each bullock was brushed with a whalebone horse-brush. The cattle were then left to ruminate and rest. At midday each bullock received another bushel of swedes, and a repetition of the dry food with the addition of 3 lbs. of bean meal. According to this very liberal system of feeding, each bullock received 13 lbs. of cake and meal, hay, and 2 bushels of cut swedes. We conclude our account of cattle-feeding by abstracting a sentence or two from Mr. H. M. Jenkins's report upon the farm of the late Mr. Hudson, of Castle Acre, Norfolk (1869). From 100 to 140 beasts, steers (mostly shorthorns), are bought in every year at Peterborough Fair. These steers are placed in small well-shedded fold-yards, and receive 2 bushels of roots and from 10 to 12 lbs. of linseed cake each per diem, as well as a bushel of cut hay or cut straw after the hay is finished. They begin to go off fat in January, and ought all to be sold by May.

COST AND RETURN.

The cost of fatting a bullock has often been stated to be at the rate of from 6s. to 7s. per week. It is by no means easy to arrive at an absolute result, as much depends upon the price at which the green food, turnips, and other home produce, not usually marketed, are valued. Taking a liberal system such as that employed by the late Mr. Hudson, of Castle Acre, the linseed cake alone would, at £12 per ton, cost 1s. per day, and the hay, roots, and attendance might increase the amount by 6d., making in all 1s. 6d. per day, or 10s. 6d. per week. Mr. M'Combie, of Tillyfour, Aberdeenshire, considers his show bullocks cost him above 12s. per week, while another agricul-

turist has estimated the cost of ordinary fatting cattle as low as 6s. per week. The cost of feeding cattle of ordinary size may be thus calculated:—

	d.
6 lbs. of linseed cake per day, at £12 per ton	7·7
4 lbs. of barley-meal, at £8 per ton	3·2
56 lbs. of turnips, at 5s. per ton	1.5
5 lbs. of hay, at £4 per ton	2·1
Attendance at the rate of $\frac{1}{40}$ of the wages of one man, at 14s. per week	0·6
	15·1

According to this estimate, the cost would amount to 15d. per day, or 8s. 9d. per week.

The question of return is still more difficult to solve. Cattle pay for their food by the manure they leave, as well as by beef produced. The fact that cattle are looked upon by many agriculturists as mere manufacturers of manure, indicates that there is not much direct profit. In other words, if an animal pays for all that is expended upon it without leaving any profit, the farmer is still satisfied, because he has the manure for his land. If a bullock lays on 1 stone (14 lbs.) of beef per week he is doing well, and a glance at the foregoing estimates of cost clearly shows that, with beef at 8s. or even at 10s. per stone, there is no great room for profit, while at the same time neither interest nor risk is charged. We have heard of bullocks increasing at the rate of 3 lbs. per day, but this must be viewed as an extreme case, doubtless caused by an extra allowance of food. In spite of the recent high prices of butcher's meat, it is therefore evident that the winter feeding of bullocks is not highly remunerative, when the grazier purchases lean stock at an extravagant price. Either by very judicious and fortunate purchases, by taking advantage of favourable changes in the market, or better still, by bringing up calves, and thus avoiding the extreme prices now realised by lean stock, the fattening of cattle may be made a profitable occupation to the agriculturist.

SHIP-BUILDING.—XX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

WATER-TIGHT FLATS.

NEAR the extremities of ships, and below the lowest complete deck, partial decks or platforms are very often constructed, to form the floors of store-rooms, etc. These platforms are usually supported upon light beams, and in some cases are of considerable length. In addition to their usefulness in the particular just stated, they add to the strength of the structure, forming strong ties between opposite sides, and helping to support the bow in case of collision. This is true in all classes of ships, whether wood, iron, or composite; but in iron ships such platforms can, by means of light plating worked upon the beams, be also turned into horizontal water-tight partitions, adding much to the safety of the vessels. In fact, this method of water-tight subdivision is well adapted for use at those parts where the forms of ships necessarily become very fine, and is probably preferable to other methods of subdivision. As an example in point, we may refer to the iron-clad ships of the navy. Their double bottoms do not extend throughout the length, but only over, say, two-thirds of the length, leaving something like one-sixth of the length at the bow, and another one-sixth at the stern, without the protection of an inner skin. At or near the endings of the double bottom, transverse water-tight bulkheads are placed; and from these bulkheads to the extremities water-tight platforms, or flats, are built. The sizes of the compartments so enclosed are not large, because the form is very fine at these parts; and they are subdivided in nearly all cases by transverse bulkheads, as well as by the partitions built in the hold for special purposes—*e.g.*, for stowing the cables, provisions, and stores, for enclosing the shaft-passage, etc. By all these arrangements a comparatively minute water-tight subdivision is secured, without fitting an inner skin; and the advantage gained will be seen more clearly when it is considered that the section of the flat, at any cross-section of the ship near the extremities, corresponds roughly to the base of a triangle, of which the two sides would have to be plated over if an inner skin were fitted. In the *Great Eastern*, we believe, the inner skin is continued quite forward to the bow, but ended some distance from the stern. Mr. Scott Russell has, however, since expressed the opinion that it would have been better not to have followed this course; and from the foregoing considerations the reason will be obvious.

It need hardly be said that all openings or hatchways made in water-tight flats, for the purpose of gaining access to the spaces below them, must be supplied with water-tight covers of some kind. It very often happens that the spaces below the flats are not made use of, being very confined, and only visited for the purpose of inspecting and cleaning or painting the framing and plating. The openings, or man-holes, in the flat can then be closed by simple plate-covers, secured by nut-and-screw bolts, red-lead or some other material being used as a "stop-water" in the joints, and the covers being nearly always in place. Where use is made of the space below a flat for stowage—as is not uncommon in large ships—it is necessary to leave the hatchways open under ordinary circumstances, providing some form of scuttle or cover that can be quickly closed and secured in case of need. One of the simplest and best plans is to hinge the scuttle to one side of the framing round the opening in the flat; and then on any sudden alarm the scuttle can be turned down into the rabbet formed to receive it, its security being ensured by catches similar to those fitted to hinged water-tight doors. India-rubber beading is also commonly fitted in the rabbets of these scuttles to make the joints water-tight. Other plans of scuttles have been fitted, but we need not describe them, as they are only minor features of construction.

It will be remembered that the main objection to the use of closely-spaced transverse bulkheads in merchant ships is based upon the difficulty which ensues in stowing the cargo. Admitting the force of this objection, some persons have proposed to substitute horizontal flats for transverse vertical partitions, and so to leave *long* cargo spaces without rendering the individual water-tight compartments so large as to compromise the safety of the ship. One of the best schemes of this kind was patented by the late Mr. Lungley, who termed it a plan for constructing "unsinkable" iron ships. It may be briefly described as follows:—The cargo-hold is subdivided by several horizontal platforms, formed of water-tight plating. To each of the spaces thus enclosed, access is obtained by means of a water-tight "trunk" or "shaft," leading up to the height of a deck, situated considerably above the loadwater-line. Cargo would be introduced into the several spaces down through these trunks; and it will be obvious that if any one of the compartments were "bilged," the water which entered would be confined to it, and to the trunk connected therewith. The lowest water-tight flat really constitutes an inner skin, as it was intended by Mr. Lungley to place it so low down in the vessel that no cargo should be stowed below it. In steamships, the intention was to place the machinery in compartments constructed on the usual plan, with transverse bulkheads; and other transverse subdivision was to be introduced where it did not interfere with the stowage. Although favourably mentioned by several authorities, this plan has not found favour with ship-builders, nor does it seem likely to do so. It involves additional cost in construction, and moreover does not lend itself so readily as other plans to the efficient combination of structural strength with lightness and safety.

It may be interesting to refer in passing to other proposals that have been made again and again, especially in connection with ships of war, to render them practically unsinkable by means of minute water-tight subdivision. The matter is deserving of attention, because the progress made in the construction of powerful guns, the use of torpedoes, and the employment of steam-rams, has led many persons to believe that the use of armour-plating for the protection of war-ships will have to be discontinued, and "unsinkable" unarmoured ships built instead. Into this discussion it would be out of place to enter here; but it should be noticed that great practical difficulties would require to be overcome, before the subdivision could be made so minute as to give the desired degree of safety. Room must be had, for example, for the engines and boilers, and so some large compartments must be formed. Moreover, convenience of stowage in magazines, shell-rooms, store-rooms, etc., would have to be sacrificed, and all facilities for communication between different parts would be done away with. Improvements

in many respects, particularly in the construction of marine engines, may do much to remove these difficulties; but at present the preferable and most natural course appears to be that actually followed in our armoured ships—viz., to provide a good double bottom and numerous main transverse bulkheads; then utilise to the utmost possible extent the partitions erected primarily from considerations of stowage; and supplement this by such further water-tight subdivision as may be conveniently applicable.

PARTIAL BULKHEADS.

A description has already been given (Vol. III., page 182) of the partial bulkheads, or deep plate-frames, fitted in ships built on Mr. Scott Russell's longitudinal system. Strengthenings of a very similar character are sometimes fitted in ordinary iron vessels, with transverse framing, at parts where special transverse strength is required, or in cases where experience proves that the strength provided originally was insufficient. With numerous transverse bulkheads they are not, of course, needed; but when the cargo-holds are very long, and especially at parts adjacent to the main hatchways, where the decks are cut away considerably, such partial bulkheads are of considerable value. They consist simply of a deep plate-frame with single or double angle-irons on the edges. The plate-frame has often to be made in several lengths, which are well fitted and strapped at the butts, in which case the frames extend from gunwale to gunwale. In other cases the partial bulkheads are only extensions of the main transverse bulkheads, being fitted above the decks at which those bulkheads end. The latter arrangement has been adopted also in a few wood ships, which have transverse bulkheads in the hold and iron deck beams.

Under this head it will not be out of place to describe briefly the stern strengthenings fitted to the recent wood-built screw steam-ships of our navy. One of the great difficulties to be overcome in constructing such vessels, is to give to the overhanging stern that amount of strength which is needed to resist the severe local strains produced by the action of the screw propeller. The weakness at the stern displayed by many merchant steam-ships built of wood, had much to do with the rapid introduction of iron steamers; and in some of the finest unarmoured wood ships of the navy similar weaknesses were developed, the stern drooping and working considerably in spite of the precautions taken. Various means were tried to obviate this evil, one of the most common being the use of strong metal knees bolted under the ship's counter, and against the sides of the stern-post. Again and again, however, these knees were broken, until they were made of massive proportions, and even then the strains due to the propelling apparatus were not satisfactorily met in vessels with great steam power, until a simple but efficacious arrangement of internal iron strengthenings was devised, which has proved most successful in all cases. Its main features are as follow :—

The beams of the deck to which the upper ends of the stern-posts are connected are covered with strong iron plating, from the fore or body post to the stern. Between the two posts, and upon the inside of the counter, a strong iron-plate knee is fitted at the middle line, and connected with the posts and the counter by double angle-irons. In wake of each post, and between it and the ship's side, strong transverse bulkheads are fitted, their upper edges being riveted to the deck plating, and their other edges connected with the posts and the ship's sides by double angle-irons. The upper parts of the posts, within the ship, are covered with strong iron plates, in order to ensure a satisfactory connection between them and the iron strengthenings. It should be added that large holes are cut out of the central portions of the transverse bulkheads—thus turning them into "partial" bulkheads—and that stiffening angle-irons are fitted around the edges of these holes. These main strengthenings are supplemented by iron hooks and braces on the lower part of the stern before the body-post, by short iron flats on the lower-deck beams, and by external metal knees under the counter, all of which contribute to the rigidity of the stern.

Iron screw-steamers, even of the greatest power, can be made sufficiently strong at the stern without any of these supplementary strengthenings. In the extremely fine part of the run abaft the stuffing-box bulkhead, it is usual to form the lower portions of the transverse frames of lightened plates, with angle-irons on the edges, and in some cases horizontal frames, or flats, are combined with these transverse frames. No other features worthy of note on account of their speciality are generally adopted.

HOG-FRAMING, ETC.

Under this head, we desire to glance at some special forms of longitudinal strengthening used in American river steamers, and a few other vessels, but not common in sea-going ships.

It is well known that American river steamers have enormous superstructures built upon comparatively light and shallow hulls, being in fact floating hotels of two or three storeys in height. Moreover, their weights of engines, boilers, etc., are disposed in a very unusual manner, being often concentrated in very short spaces of the length; and this fact, taken in connection with the excessive fineness of form given to the hull, in order to attain high speed, renders the longitudinal bending strains brought upon the structure very great. The question arises, therefore, how is the necessary strength supplied, seeing that the superstructure is built almost exclusively with a view to accommodation, and helps the hull proper scarcely at all? And the answer is, by means of the hog-frame, or some similar plan. These hog-frames are really strong timber girders, capable of resisting either tensile or compressive strains, and are sometimes two or three times as deep as the hull proper. When so high they are built as follows :—Strong vertical struts of timber are erected, and strongly secured at the heels to some portion of the hull. Upon the heads of these struts a strong longitudinal scarfed beam is fitted, and forms the top of the girder. Diagonal struts are also fitted between this beam and the hull, in order to maintain the rigidity of the girder. Our meaning will perhaps be more clearly understood, if we say that these hog-frames may be fairly compared to the side-girders commonly fitted to timber bridges, and help the shallow hull just as those girders help to sustain the platforms of the bridges.

In cases where less strength is required, shallower hog-frames will suffice, and sometimes these are built in the hold, the vertical struts then being heeled on strong longitudinal keelsons, and made to extend up to longitudinal beams fitted under the lowest tier of deck-beams. It is interesting to remark that this latter arrangement, which is now extensively used in America on the western rivers, is identical in principle with a plan proposed by the great French writer Bouguer, more than a century ago. He was much impressed with the excessive hogging commonly occurring in the ships of that period, and to remedy it, proposed to construct what we should now call a hog-frame at the middle line, the keelson forming the lower flange of the girder, and a continuous carling or longitudinal beam being fitted under the lower deck beams. This plan is obviously applicable to sea-going ships, but the first-mentioned, where very deep hog-frames are employed, would scarcely be so. Of course, river steamers are not subjected to such severe strains as sea-going ships have to resist; but, on the other hand, the latter class in nearly all cases have the hull proper much deeper than that of river steamers, and (as was before shown) this increase in depth leads to a very great addition of strength in the hull itself, supplementary strengthenings not being so requisite, if at all required.

Before passing on, it may be interesting to add that the Americans generally end their hog-frames at fifty feet or so from the ends of the steamers, and that they support the extremities by means of what they term "masts and guys." This is a very simple but apparently effective device, and consists in erecting strong masts at parts of the ship where there are excesses of buoyancy, and then leading chains or "guys" from the tops of the masts down to parts, especially near the bow and stern, where there is an excess of weight. It will be obvious that, while this plan may answer very well in river steamers, where the strains at the bow and stern always tend to make those parts droop, it would not be applicable to sea-going ships, which when at sea may be subjected to sagging strains throughout the length. The guys are, of course, only efficient against tensile forces, and are only strained in that manner in the cases where they are employed; they are also subjected to no sudden and great variations of strain, like those experienced by the structure of a ship at sea. We mention these arrangements, therefore, rather as examples of simple plans adapted to particular uses, than as suited for general application, or as illustrating principles of construction.

In some iron and steel shallow-draught vessels, built for

service in the rivers of India and elsewhere, lattice-girders, serving the same purpose as hog-frames, have been fitted. With iron or steel, such girders can be made both stronger and lighter than when built of wood, and are also most simple in construction. It may be that hereafter girders of a somewhat similar character will be used as strengthenings in sea-going ships, if their dimensions be much increased as compared with our present ships, and a longitudinal system of framing be adopted. In bridge-construction the lattice principle is now very extensively employed; and, although not so well adapted to ship-building, it appears probable that the same principle may be applied to some extent with advantage.

In concluding these remarks on some of the principal special provisions for strength and safety, we would once more remind our readers that, within the limits of this series of articles, it is impossible to do more than sketch the main features of ship-construction; and we would refer such as may desire a fuller acquaintance with the subject, to the numerous published works giving detailed information.

MINING AND QUARRYING.—XXIX.

BY GEORGE GLADSTONE, F.C.S.

SILVER.

ORES—ASSOCIATION WITH GALENA—GEOGRAPHICAL DISTRIBUTION—ASSAYING—SEPARATION OF SILVER FROM LEAD—PATTINSON'S PROCESS—ACTION OF ZINC.

STRICTLY speaking, it can hardly be said that we possess any silver ores in the British Isles, though, as has been stated in Article XXIV., the production of silver in this country is very considerable. It is true that specimens of native silver, as well as some of its ores, extracted from British mines, are to be found in mineralogical cabinets; and also that some of the Cornish mines have yielded native silver, and the sulphide and arsenide of silver to the value of some few thousand pounds sterling. In no case, however, have these mines been worked for the sake of this metal alone.

It is as an almost constant associate of lead that we look for our supply of British silver. Those ores of lead which occur in the older rocks, such as the lower Silurian and Devonian, generally contain the largest per-centage. Thus the lead ores of the Isle of Man yield fifty to sixty ounces of silver to the ton of lead, those of Cornwall and Devonshire about thirty ounces, those of Cardiganshire and Montgomeryshire fifteen to twenty-five ounces; while the great deposits of lead ore in the Carboniferous limestone often yield so little, as not to be worth the cost of separation. The annual yield from this source is steadily increasing; the average produce of the British mines for the ten years ending with 1868 was 666,804 ounces, while the two last of the decade contributed to this average 805,394 and 841,328 ounces respectively.

The principal European supplies are drawn from Spain, where genuine silver ores occur; from the Austrian Empire, in which the silver is for the most part associated with copper; and from Saxony and Prussia, where the ores consist principally of argentiferous lead.

More than three-fourths of the whole supply of silver comes from the New World. Mexico, until within the last few years, has always headed the list by far; but the great discoveries of late in some of the most recent acquisitions of the United States have caused even Mexico to be outdone by its modern rival. The whole of the mountain chain which may be considered the backbone of America, extending from the southern Andes in Chili to the Rocky Mountains in the north, is more or less argentiferous; and the produce throughout the whole length of this region would be very much greater than it is at present, were there a larger working population, and greater facilities of communication.

The assaying of silver ores, so far as concerns Englishmen, will principally have reference to the argentiferous lead; but something should be said as to how to treat silver ores proper, as they are always liable to be met with, especially in mining for copper. If they contain much earthy matter, they may generally be most conveniently treated by fusing them in an earthen crucible with some carbonate of soda and borax, and more litharge than is necessary to take up the silver in the ore, so as to yield an alloy which shall be moderately rich in the precious metal. The mixture is melted in an ordinary assay-furnace, until the slag has become quite liquid; it is then poured out into an iron mould, and on cooling, the button of alloy will be found at the bottom. This has then to be cupelled in order to separate the silver from the lead. The cupel, upon which this operation is conducted, is made of bone-ash ground up with water, pressed into a mould, and hollowed out in the centre. The cupel, which must first be perfectly dried, is placed in the muffle of an air-furnace, and gradually raised to a bright red heat. The button of alloy is then placed in the hollow of the cupel, where it soon melts; and the air passing through the muffle over the surface of the metal, oxidises the lead in the alloy, and converts it into litharge. This is absorbed by the bone-ash of the cupel as fast as it is formed, and so the silver is ultimately left behind in a state of purity. When cold, the bead of silver is taken out and weighed; from the weight has to be deducted the quantity of silver that may have been present in the litharge, and the result will be the quantity of silver in the ore. This correction for the silver introduced through the litharge is necessary in all exact determinations, but it occasions little trouble in practice, as one testing of the litharge will suffice for a whole parcel; the litharge itself is tested by cupellation, and if necessary, can be done simultaneously with the other.

If the silver ore contains a large proportion of the sulphides of other metals, it may be conveniently assayed by the scorification process. In this case, the pounded ore is put into an open earthen dish, with an excess of granulated lead, and some borax. This is heated to a bright red heat in the muffle of an assay-furnace. A portion of the lead being soon converted into litharge, enters into combination with the metallic sulphides, forming with them, the earthy portions of the ore, and the borax, a fusible slag; the excess of lead is thus protected from the action of the air, and remains in the metallic condition, uniting with whatever silver there may be in the ore. A button of silver lead is the result, which has then to be cupelled as before, and a proper allowance made for the silver originally contained in the lead.

The assay of silver lead ores has been partially described when treating of the inferior metal. For the purposes of sale, the ore must be assayed first to ascertain the quantity of argentiferous lead, and then the relative proportion of silver and lead in the product must be determined. From these two data, the value to the smelter can be calculated. The former part of the process has been detailed in Article XXIV.; and the latter will now need no further description than to say that it is done by cupellation, exactly as the button of alloy produced in the assay of silver ores is treated.

We must now turn to the separation of silver from its other associates on the large scale. The chief of them is lead. In former times it used to be separated from this metal by cupellation alone, a plan which is still adopted at many Continental works, but which has been almost entirely superseded in England by a more convenient one, known by the name of the inventor, the late Mr. Pattinson of Newcastle.

Pattinson's process is dependent for its action upon a curious property of the ordinary alloys of silver and lead—viz., that they melt at a lower temperature than pure lead does. This rule applies to any compound of the two metals in which the proportion of silver does not exceed $2\frac{1}{4}$ per cent.; but as this per-centage is equivalent to a yield of 735 ounces to the ton, it will be seen that the limit vastly exceeds in richness the produce of the most valuable ores. The consequence of the alloy melting at a low temperature is, that on slightly cooling the molten mass, a redistribution of the particles takes place, and a portion of the lead tends to crystallise out. By removing the crystals before the rest of the metal solidifies around them, and repeating this operation several times, the crystallised lead becomes almost entirely freed from silver, and the remaining alloy becomes gradually enriched with the precious metal, until it nearly reaches the limit above stated. The desilvered lead rarely contains more than one-half to three-quarters of an ounce to the ton, or about 0·002 per cent., beyond which point it is not found profitable to carry the operation.

The plan by which this process is carried out is as follows:—From eight to ten or more iron pots are placed in a row, and sunk into a platform of brickwork, beneath each of which is a

separate furnace, with a wheel flue passing below the whole of the under surface of the respective pots before passing away into the common chimney. Fig. 1 shows a cross section of the row of pots from back to front. A represents the pot sunk into the brickwork, B; C the furnace, with the ash-pit, D, below; E E E show the arrangement of the flue encircling the under side of the pot, before passing into the general flue F. The platforms G and H, for the men who attend to the pots, extend the whole length of the row. Each crystallising or Pattinson pot, as these are often called, is hemispherical in shape and about five feet in interior diameter. The outside pot on the left hand is rather smaller than the rest, and is distinguished by the name of the "market pot." Each of the crystallising pots will conveniently hold about $6\frac{1}{2}$ tons of melted lead.

Suppose a series of ten pots are used, and that the crystallising pots are numbered consecutively 1 to 9, No. 1 being next the market pot. In all of them, with the exception of the market pot, there will be a quantity of lead more or less rich in silver remaining over from the last shift. The fires are got up, attention being first given to pot No. 5, the central one of the series, in which the process of separating the silver will be commenced. This pot is filled up with the lead to be desilverised, and the fire below it is kept up till the whole is thoroughly melted. As soon as this point is reached, the lead is skimmed, to remove all the oxide that has formed on the surface during the melting; the fire is withdrawn, and the lead is left to cool, cold water being generally thrown upon the metal to hasten the cooling. As soon as the lead begins to crystallise on the surface, and round the edges of the pot, one of the workmen detaches the adhering crystals by means of a long iron bar shaped at the end like a chisel, called a slice, and stirs them up among the still liquid portion. Another man then takes a perforated iron ladle, and dips it to the bottom of the pot, bringing up in it a quantity of lead crystals; with a slight jerking motion, they are pretty thoroughly freed from the liquid portion which runs through the perforations in the ladle, and the crystals are then turned over into pot No. 4, the next in order on the left hand of the workman. The ladling is thus continued till rather more than two-thirds of the contents of pot No. 5 have thus been transferred to No. 4, when the remainder, consisting of enriched lead, is removed by ordinary ladles into pot No. 6 on the right. The same process is now applied to pots 4 and 6, the crystals from these being ladled into Nos. 3 and 5 respectively, and the enriched lead into Nos. 5 and 7 respectively, and so on until the market pot is reached at the one end, and No. 9 at the other end, of the series.

Thus, if we suppose a lead to be operated upon which contains twelve ounces of silver to the ton, that will represent the richness of No. 5; but as the crystals will only carry away with them a small proportion of silver, the remainder (from one-third to one-fourth part of the whole) will generally be at least double as rich as it was before the separation, and No. 6 will, therefore, be worth about twenty-six to twenty-seven ounces to the ton. By this process of addition, as the mixed metals travel to the right from pot to pot, and of subtraction as they travel to the left, it will result that at the one extreme the lead will be found to contain some 250 ounces to the ton, while that in the market pot at the other will be practically desilverised, containing only about three-fourths of an ounce to the ton. The enriching of the lead can be carried higher if desired, but that is found to be about a convenient limit, as the crystals become each time more difficult to separate, and an alloy of such richness is well suited for the next step of the process, the cupellation.

The perforated ladles above mentioned are about sixteen inches in diameter across the bowl; and including the handle, weigh about 130 lbs.; at each lift the workman takes up about 250 lbs. weight of crystals. The handle rests, when the ladle is full, upon a block at the side of the pot which serves as a fulcrum, the long arm of the lever being in the hands of the workman; but, nevertheless, the work is rather heavy. In some establishments, therefore, cranes are used as a substitute for manual labour, a crane being fixed between each two successive pots; and then ladles which will hold double the quantity of crystals can be employed, pots which will hold about ten tons of metal being generally adopted in such case.

As the perforations in the ladles are apt at times to get clogged with the cooling metal, it is usual to have small pots, called temper or wash-pots, placed between every second crystallising pot, containing hot lead of the same richness as that in the pot from which the ladle has been taken. In some works, however, these are dispensed with, and the ladle is reheated by being dipped for a while in the hot lead contained in the pot to which the crystals are being transferred.

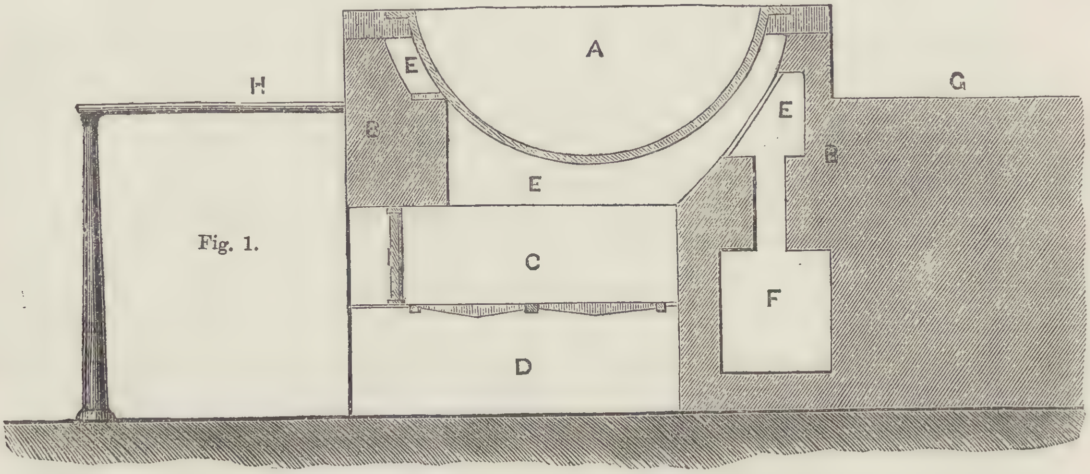


Fig. 1.

The loss of metal in skimmings, when a series of ten pots is used, will amount to nearly one-fourth of the whole quantity; but the skimmings are utilised by re-conversion into metallic lead, so that the ultimate loss is very small.

Silver may be separated from lead by other processes besides cupellation, and that of Mr. Pattinson; one of the most convenient of these, though it has not held its ground in competition with the others, is due to the action of zinc. It is found that if about 5 per cent. of zinc be added to any given quantity of argentiferous lead, and the metals be mixed together in a liquid state, the silver will separate itself from the lead and combine with the zinc; and as the latter has a higher melting-point than the former, the zinc on cooling will crystallise out first along with the silver, and form a layer on the surface of the lead, which can be separated with readiness. It will be remembered that in Article XXIII. zinc was spoken of as being highly volatile, and as silver is only very slightly so, the inferior metal can be removed by distillation in retorts made upon the Belgian principle; or it can be separated from the silver by dissolving it in weak sulphuric or hydrochloric acid. This principle, with certain modifications rendered necessary by the peculiar character of the ores from which the lead is made, has been adopted with greater success at some of the smelting-works on the Continent.

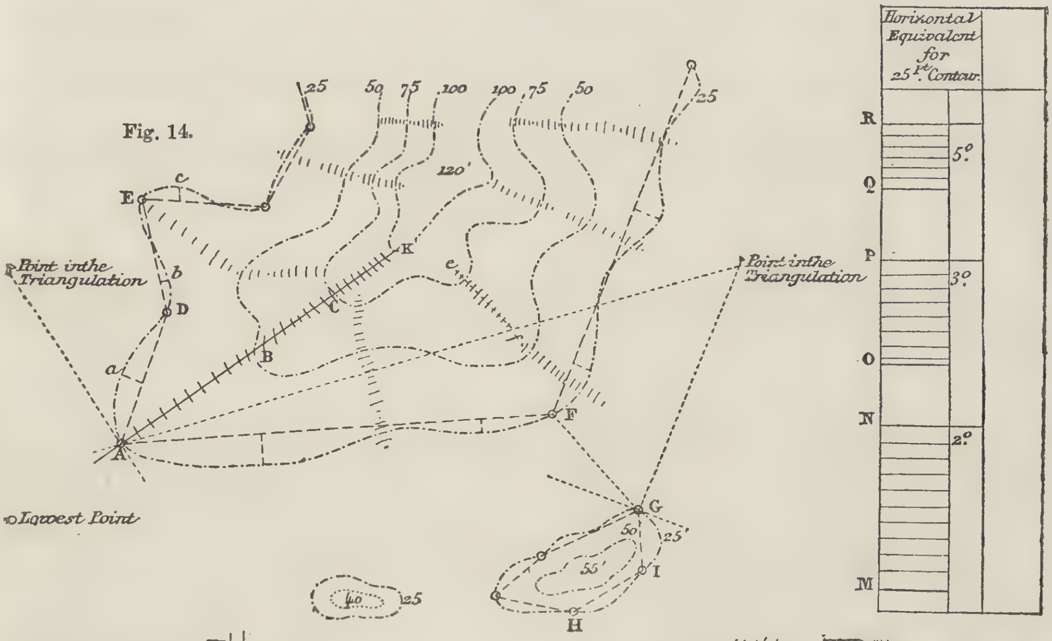
MAP AND PLAN DRAWING.—V.

By C. C. King.

METHOD OF CONTOURING.

It is not always absolutely necessary to run a system of contours or levels through an area, though whenever time is afforded it is advisable to do so, not only because of the greater accuracy of the relative heights of different points, but because it enables the draughtsman to obtain a much better appreciation of the sketch. When the exact altitude of the lowest point above the surface of the sea is known, the contour lines at any chosen distance apart, say 25 feet, will be enumerated from its exact height; thus if it be 200 feet above the sea, the contours will number 225, 250, 275, and so on. But where this cannot be ascertained, the lowest point is marked zero, and the contours and altitudes will only refer relatively to that point, and will be 25, 50, etc. It may be remarked that the intervals between the contours depend somewhat on the scale of the drawing.

Fig. 14.



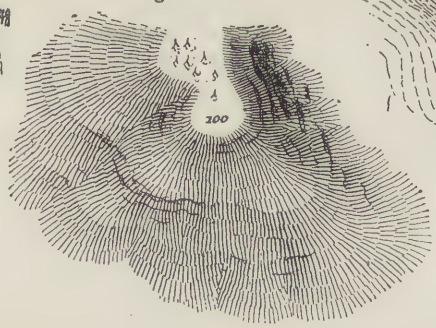


Fig. 15.

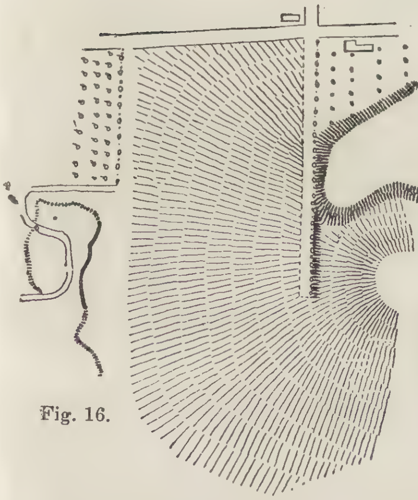


Fig. 16.

Fig. 17.

intricacies of the country, and hence much facilitates his sketching those features. Where the extent of ground is not large, where the differences in level are very slight, or where again they are not numerous, as would be the case if a small solitary hill alone broke the general flatness of the surface, it would scarcely be worth while to trace regular contour lines; but as this would rarely occur, it will be well to treat contouring as a step in the work which can be omitted if the nature of the country does not demand its being carried out.

We have before defined what contouring is. It means simply describing level lines at stated regular intervals of altitude which intersect the area and follow the windings of the hills and valleys. It is evident, therefore, that some point must be selected to start from, and this is termed the datum level of the Thus with one inch to a mile they are usually 50 feet apart; from this to six inches to the mile the interval is 25 feet, and with larger scales 10 feet. In either case it is best to select one of the highest hills, and ascertain its height as carefully as possible, marking by pickets the points through which the contours will pass—that is, at 25 feet intervals above the lowest point in the sketch. This can be done with sufficient accuracy by the small clinometer before described. The observer, holding it horizontally, will note where the prolongation of the upper surface cuts the front of the hill before him, and knowing the height of his eye above the ground, he will, on walking to the point he has observed, have ascended that height above his starting-point. By repeating the operation he will gradually ascend the slope, and the position of the contour lines will be

marked as he rises successively 25 feet above the datum level. Starting from any one of these points, he will direct the clinometer on all the prominent or re-entering features of the hill or range of heights, and notice such points as may appear to be on the same level, and taking the bearing of the nearest with the compass, he will measure or pace the distance to it. From this point a second level and a second bearing are observed, and the interval measured, the process being continued until the entire hill is traced. Outlying isolated hills may be on the same level as the starting-point, but being separated by valleys from the hill on which it is situated, the contour line passing through it will not, of course, be continuous with that indicating the form of the hill itself. In this instance a point on a level with one of the contours, and situated on the "outlier," is carefully observed; and then, with this as a fresh starting-point, the contour is traced around the hill by bearing and measurement, and marked with the same number as that on whose level it is. Thus, in Fig. 14, A, B, C are the starting-points of contours at 25 feet vertical interval, and their position is traced on the paper by finding the true place of A by interpolation, taking the bearing of the line A C, and measuring off on it the distance measured between the pickets A, B, C; or if the slope be very steep, tracing these measurements reduced to a horizontal plane. The picket A has been selected for the first starting-point, and thence the points D, E have been successively observed, and the intervals A D, D E measured and transferred to paper. But near F lies the hill G, and when the surveyor reached this point he noted that the tree or other object at G was on the same level; proceeding to this point, and fixing it by interpolation or by bearing and distance from F, he then completed the small continuous contour G H I, etc.

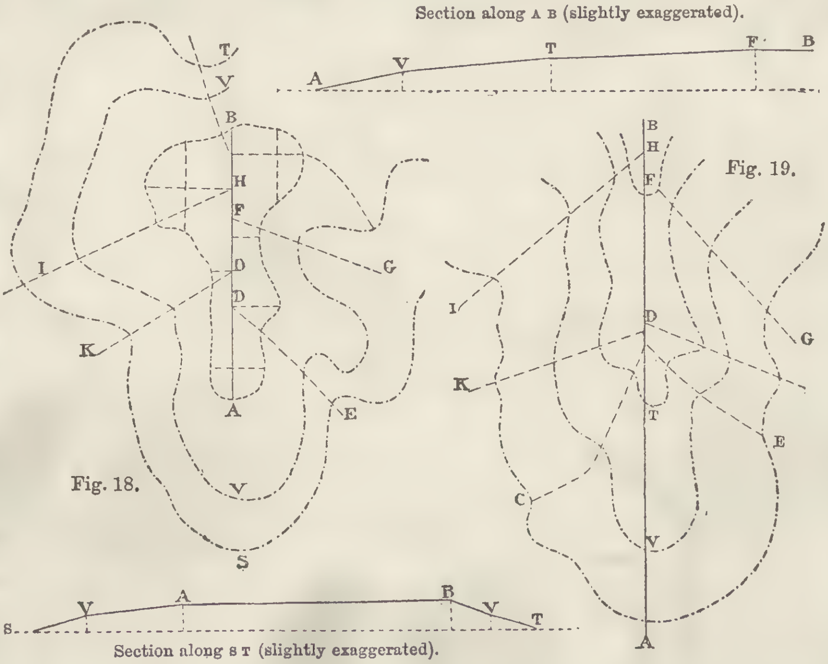
These are then numbered according to their elevation, and are traced usually in colours, either blue or red, with a dotted line. It will be noticed that when the curve is short it is considered sufficient to take bearings across the arcs, and either sketch them in by hand or pace to the distance of the farthest point of the curve from the bearing, as shown at *a b c* (Fig. 14). These levels will evidently determine the relative height of nearly all the features; but where, as at H, the hill-top lies between the contours—that is, about 55 feet high—its altitude is ascertained from any known point on the contour by levelling up by repeated operations until the summit is reached. In many cases the heights may be approximately measured by eye, and in others the angle of elevation above the lowest point may be taken by the clinometer, and the height of the hill above this be found by calculation from a table generally printed on it.*

* This table is one of natural sines, and contains two columns, one of angles from 1° to 60°, the other the decimal numbers representing the natural sines of these angles. Thus, suppose the distance of the hill-top from a known point A was either actually chained or else taken by scale from the map, and found to be 400 yards, and at the point A the angle taken by directing the top edge of the clinometer on the summit of the hill was observed to be 3°, we should look in the table for 3°, and multiply the number ·0523 opposite it by 400, which would give us 62 feet nearly as the height of the hill.

In conducting this portion of the work, as well as in traversing the roads, it is advisable to correct the position of the observer at various convenient points by taking the bearings of any of the prominent features of the triangulation and interpolating the result. This will frequently show an error in "place," especially if the line traversed or contoured be intricate, and where the time at the disposal of the surveyor is short, a large amount of useful and approximately accurate work can be done by simply fixing a series of points in this manner, and, without measuring their distance apart, sketching by eye the intermediate portions. This necessarily requires practice, but the results obtained are, when experience is gained by repeated attempts, singularly trustworthy, and, by showing the nature of the ground, are of very material assistance in filling in rapidly the shading of the hills.

The contouring glass, a simple and very portable instrument, giving very good results, may also be used for ascertaining the position of the contours. It is a small brass tube provided with a spirit-level, and a reflecting glass is so arranged that on looking through the tube the bubble of the spirit-level is seen when the tube is held horizontally. Crossed wires intersecting in the axis of the tube are fitted in the object-glass, and when the bubble is visible in the reflector, the intersection of the wires, and a point on the hill-side in the prolongation of the line of sight, are on the same level.

Section along A B (slightly exaggerated).



Section along S T (slightly exaggerated).

Altitudes may again be determined with considerable accuracy and with great saving of time in mountainous districts, where the differences in level are more marked, by means of the pocket aneroid. It resembles a watch in size and appearance, being, therefore, extremely portable, and is graduated in feet. An error of 10 or 12 feet in 100 should rarely be exceeded, as it is but little affected by change of temperature, and if returned to the same pocket after each observation the results will be more correct.

Before describing the finishing steps of the work, it will be well to examine briefly the principles on which hill-shading is based. There are many different ways of representing the physical features of the earth's surface. In France, carefully traced contour lines at near intervals are described over the area, and these depict the character of the ground with great distinctness to a practised eye, while at the same time the map is not encumbered with drawing; but it cannot convey so much information to unskilled readers as the more minute and laborious methods which depend on effects of light and shade.

There are two principal modes of expressing the nature of hill and valleys on a plan. One, the vertical, which is largely employed in France and Prussia, and also in England, when the scale is very small and the maps are to be engraved; and in this method it is assumed that the lines represent the course which the rills of water would take in descending from the water-sheds to the lower levels. It may be used simply for expression of the ground when the relative thickness or distance of the lines apart have no especial meaning beyond depicting the folds and irregularities of the ground; or the lines and distances may be constructed according to a scale of shade, as in

German military maps, where their relative thickness denotes the *angle* of the slope as well as its form. Thus Lehman's scale of shade commences with fine lines at 5°, and proceeds in increasing thicknesses of line every 5° up to 45°, which being practically impassable is represented as composed of very thick black lines, extremely close to one another. Figs. 15 and 16 show the difference in the appearance of the two methods. Contour lines are equally useful in this as in the other kinds of drawing, but the lines or *hachures* between any two contours should not exactly coincide or be in continuation of those above or below, as too much regularity detracts from the beauty of the sketch. The work should be commenced from the crest of the hill, and in the steeper portions the lines are closer and blacker than in the plains or valleys, where the hachures become lighter and more divergent.

The advantages of this style are, that in very hilly districts, where the roads run rather across the slopes, and are of a zigzag form, they are clearly shown as they cut the hachures at an angle; and in mountainous countries, such as the Pyrenees, where the spurs and ridges are very steep and uniform, vertical lines may, perhaps, express their nature better. Again, names are printed more clearly across than between a series of lines, especially if the latter be dark. The great disadvantage is, that it does not show the relative differences of level so readily as the horizontal style.

The horizontal method (Fig. 17) may be considered as but an extension of the principle of contouring, as the space between the chief contours is filled in with horizontal lines, preserving a rough parallelism to them. These hachures are not, however, continuous, as this would tend to make the drawing too smooth and even, and destroy the irregularity of work produced by drawing them in sets or groups of various lengths, which, moreover, tends to produce a nearer resemblance to the roughness of the actual surface. The pencil should be firmly held, so as to produce an even stroke, and each set should be somewhat of a diamond pattern, the axis of which is the direction of an imaginary water-course or rivulet. Thus, in Fig. 14, the line *e f*, perpendicular to the general direction of the hachure, is the axis. As in the vertical method, the hachure may either be used to express the ground, or may give accuracy as well as expression by the use of a scale of shade. The former plan produces, perhaps, neater drawing, and admits of the display of more artistic skill, but it has the great disadvantage of want of uniformity between the work of different draughtsmen, and hence a hasty survey of a large area, subdivided between a number of surveyors conjointly, becomes an impossibility, as it cannot be put together.

The scale of shade in use in England, by military men more particularly, is that of Colonel Scott, and in this system the distance between the hachures, as well as the intensity of the line, varies with the slope, the variations occurring at 2°, 3°, 5°, 10°, 15°, 20°, 25°, 35°, beyond which the slopes are practically impassable for military movements, and the delineation is left to the skill of the draughtsman. One column in the printed "scale" is devoted to giving the number of lines which for any given slope will lie between contours 25′ apart vertically, on a scale of 6 inches to the mile; thus at 2° the horizontal equivalent for each contour—that is, the base of the triangle, of which the slope is the hypothenuse—admits of the drawing of eleven fine lines $\frac{1}{12}$th of an inch apart; at 15° four rather dark lines, $\frac{1}{30}$th of an inch apart, fill the horizontal space between two contours at that slope, and so on. This arrangement is advantageous in two ways. It admits of drawing, generally accurate save in minute irregularities that may exist between contours, being executed by the aid of contour lines only; for if the spaces in the column of horizontal equivalents are applied to the plan it is evident that the space which coincides with the distance between the contours at any point gives the number of horizontal hachures of a certain thickness and interval necessary for that angle, and hence describes the slope that lies between the contour lines. Thus, in Fig. 14, if the distances A B, B C, C K, be measured and found to agree with the spaces M N, O P, Q R, on the scale of shade, a portion of which is shown, it will only be necessary to fill in the intervals with lines of the same character as those shown in M N, O P, etc. Again, we are able to ascertain the height of any point approximately by measuring the number of lines due to a certain slope by the intervals in the column of horizontal equivalents; for if there be eleven lines of the character which expresses a slope of 2°, the difference in level between the first and last hachure will be 25 feet, since that number of lines occupies a space which is the horizontal equivalent of the slope on a scale of 6 inches to the mile; if twenty-two lines, the difference in height would be 50 feet, and so on. The disadvantage of this scale of shade is, that it is weak in the description of undulating or only slightly rising ground, and a sketch completed by it is wanting in the richness which distinguishes work executed with more attention to expression than accuracy.

Lastly, the character of the ground may be represented by washes of Indian ink, neutral tint, or sepia; but this, though excellent for rough sketches, and capable of expressing very distinctly the hills and valleys, is not susceptible of accuracy, and depends too much on the individual artistic skill of the draughtsman. In shading by "brush work" contour lines may still be used, and the only care necessary in executing it is that the washes should be laid on lightly, carefully shaded off, and the effect produced rather by repeated application of the brush than by at once endeavouring to give expression to bold features by a heavy wash of colour. The early washes should be entirely of neutral tint, and when the country is faintly marked out in this colour, Indian ink should be used for finishing the sketch, the steepest slopes being the darkest.

Whatever method be employed, it is necessary to construct some framework which shall guide the drawing. If the surface of the earth were seen from a point of view some distance above it, we should notice that the level portions would appear lightest; and since the summits of the hills are usually more or less level, and, moreover, form portions of the local water-shed of the district, it is usual to begin by describing accurately, as far as possible, the hill-crests. When the area is such that no plateau or true summit is apparent, as would be the case when the survey was conducted over a large regular spur sloping definitely in one direction, the first thing traced is the main line through it, which forms the local water-shed, and which is determined by bearings and transferred to the plan. Thus, in Fig. 19, the line A B is first marked and traversed, and from it the bearings of all the main water-course lines are determined, and set off as D C, D E, etc.; and when the ground is intricate, or when prominent spurs and ridges diverge from it, these should be further marked, and will serve as guiding lines for the hachures showing their shape.

When a plateau forms the crest of the hill, a line will be taken right through it, from a point fixed by interpolation, and its form traced by offsets (Fig. 18), and the water-course and guiding lines are delineated as before.

Having thus formed the groundwork on which the hachures can be accurately drawn, and which, from having all the main features indicated by lines, will only admit of inaccuracy in the minor irregularities of the detail, the examination of the slopes themselves must be carried on.

It would be impossible, and practically unnecessary, to test the angle of slope of every portion of the area, and it is found in practice sufficiently accurate to mark carefully down the alterations in the inclination of all the principal spurs or ridges from the summit or water-shed to the base, and leave the intermediate spaces to be filled in by eye-sketching. Thus the angles of the different portions of the spurs in Fig. 14 are carefully noted down in the following way. Commencing at the summit of the hill, the angle of the slope is taken by means of the clinometer as far as it continues uniform, and the distance to the point where the alteration occurs is paced on the guiding line. This is marked on the paper, and the space filled with small hachure lines, of the nature due to the slope, according to the scale of shade. From this point a second observation of the slope is made, the result noted down, and the distance paced as before. All the small outlying features, such as hillocks or ridges, which are not united to and form part of the main ridges and their projecting spurs, are visited in the same manner, and the details of these "under-features" sketched in.

It is advisable to make a short halt after any two adjacent spurs have been traversed, and from the one which gives the clearest view to fill in the ground lying between them: this assists the workman to complete a large section of the main features entirely before turning to the under-features, which are near it. The actual manipulation of the pencil is a matter that depends entirely on natural aptitude, and even more on constant

practice. In cases where the country is so intricate as to make it difficult to indicate whether the slopes are running up or down—as, for example, in sketching a perfectly symmetrical cone, and a perfectly symmetrical hollow of a similar shape—it is usual to denote the water-courses by a small arrow pointing towards the lower level.

In reading the work it must be remembered that the summits of the hills are left blank under ordinary circumstances, and to distinguish them from a cup-like hollow the altitudes are marked in figures on them. A blank space would also be left in drawing a saddle between two hills, and would be distinguished from the hill-top solely by the nature of the surrounding drawing.

Thus we finally have the drawing of the area completed, and it simply remains to fill in any details of houses, farm enclosures, hedge-rows, or woods, by actual traversing them with a compass and a chain. Starting-points can always be found by interpolation, and thence a series of traverses taken in different directions will provide a number of intersecting bearings which will determine the minor details. In finishing up the work much can be done by mere eye-sketching, and a number of conventional signs, altered to suit the scale of the plan, are adopted to facilitate the expression of the ground. Any particular way of delineating certain unusual characteristics that may occur can be employed so long as a reference is made to it in a column of remarks.

Nothing more remains to be done, except to draw the scale, add the names of all the places, and the direction of all the main roads—that is, whence they come, with the distance from the nearest town, and whither they lead, with the distance to the next place of importance. The directing lines which were made for the use of the prismatic compass and protractor, will give us the position of magnetic east and west, and in a convenient corner the magnetic north is indicated by an arrow, while the true north is also denoted by an arrow, inclined at an angle to it, dependent on the variation of the compass.

This may be ascertained by previously taking the magnetic bearing of a point known to be due north of the observer's position, or, if none exist, by taking the bearing of the centre of the sun as it crosses the meridian. For this it is necessary to have the instrument fitted with coloured glasses, capable of being moved over the prismatic sight, and a mirror attached to the sight-vane in which the vertical wire is fixed; but it is essential in making the observation that the compass should be horizontal, and it had better be placed on some level surface.

The time when the sun is crossing the meridian is known by referring to the Nautical Almanack on the given date, and subtracting from the known local time the difference between the sun time and mean time given in the tables.* This will give the moment, according to the local time, when the sun is on the meridian. It is evident that in northern latitudes the bearing observed will have to be subtracted from 180° to give the variation as the sun is to the south of the observer. The bearing of the pole-star may also be taken, but this is not an easy matter, on account of the difficulty of reading the compass bearing when the star is in its right position. It adds much to the value of the plan in many instances if a section of the survey on any given alignment be given. This is produced by drawing a line across the plan, as A B (Fig. 19), and measuring off on it from one end, A, the positions of the points through which the contours pass, or where any undulating alterations of level occur. A horizontal line is then traced, and these distances transferred to it, and from the points thus marked a series of vertical lines are drawn, on which are measured respectively the heights of the several points, which may be ascertained from the plan itself.

* Under the head of "Equation of Time."

GREAT MANUFACTURES OF LITTLE THINGS.—X.

SCREWS.

BY CHARLES HIBBS.

In tracing the progress of man from savagery to civilisation, we are generally oppressed with the idea that it has been a slow, painful, and laborious journey. But here and there we come upon the record of some happy invention or discovery, which has enabled him to make a sudden start forward, and clear a great space at a bound. Such was the invention of printing, and such the successful application of the power of steam. It would seem, however, with all the boasted rapid advance of modern times, that antiquity was vastly richer in those sorts of discoveries which begin epochs, and give a new and tremendous impetus to human progress. The old discoveries seem to be of far larger importance than the new, and to have had far more influence upon the destinies of mankind. How insignificant, for instance, is the invention of printing, compared with that of written language itself—the representation by inscribed characters of the sounds of the human voice, and their reduction to an alphabet! How profitless would have been the discovery of the expansive force of steam if there had not previously been made the far greater discovery of the mechanical powers which it sets in motion—the lever, the wheel, and the screw! We might speculate curiously as to who made the first screw. The saw was reckoned so wonderful an implement that its inventor was ranked among the gods. Was the same honour awarded to the inventor of the screw? If it could have been foreseen how important and various were the offices it would be made to serve, how immensely human effort would be aided by it, there would have been no question in those days about assigning to it a superhuman origin.

The screw, as the mechanical student is of course well aware, is simply a modification of the inclined plane. A winding road round a hill, or a winding stair by which the summit of a tower is reached, will be familiar illustrations of this fact. A common wood screw enters a piece of wood in the manner of a wedge, or movable inclined plane, with the difference that it acts in a circular instead of in a direct line. When a lever is connected with the shaft of the screw, as in an ordinary vice-pin, there is a combination of two powers; and when weights are affixed, as in the loaded arms of a fly-press, there is the addition of momentum, which together produce an almost irresistible force. These considerations belong rather to the abstract science of mechanics than to the subject of these papers, which treat principally of manufactures; but may be usefully alluded to here as illustrating the principles which should guide production.

If a strip of paper be wound round a shaft of wood—say a lead pencil—at an angle, it will be found that its edges fall into a position resembling the threads of a screw. This was, indeed, the method formerly used for originating the large screws used in machinery. A piece of paper was cut into the shape of an inclined plane, *i.e.*, a right-angled triangle, the height of which corresponded to the length of the shaft of the intended screw, and the hypothenuse to the inclination or pitch of its threads. This was wrapped round tightly and pasted to the shaft, and a nick made with a file along the spiral line formed by its edge, the indentation being afterwards deepened until from the incipient worm a nut could be formed, which served as a holder or guide for the cutters that were to complete it. After the pattern screw was made any number of copies could be produced from it, by processes we have yet to describe; but it was often a matter of importance to get a true thread of a new size or pattern, and many were the contrivances adopted for the purpose. A workman at Soho employed the following modification of the paper method:—He first of all turned his cylindrical shaft perfectly true, and then cut a strip of paper of the same length, whose width would just encircle the shaft when pasted round it, the edges coming together accurately. Before pasting it on he had marked it with a series of diagonal lines, drawing them from points made by compasses along the sides at intervals equal to the distance which one thread of the screw was intended to traverse. When it was cemented to the shaft, these lines ran into each other and formed a continuous thread, along which he made a series of indentations in the metal by means of a centre punch and a hammer, afterwards connecting them with a file. We may readily conceive that this method would admit of greater nicety of manipulation than the last, because there would be only one thickness of paper to cut through before reaching the iron. When he had produced a roughly-formed thread, he suspended the shaft in a box properly contrived, and cast round a portion of it a block of lead, the impressions in which served as cutter guides. A ruder method was to wind a piece of iron wire obliquely round the shaft, and form a mould from it by compression, with the same object of getting a guide for the cutters. A more

scientifically elaborate, though still primitive, method of originating screws is described in the *Philosophical Transactions.* Two straight edges are fixed parallel to each other upon a table, the distance between them being exactly equal to the length of the screw-shaft. Their own length must be equal to as many circumferences of the shaft as the thread is intended to traverse it, which depends, of course, upon whether the screw is intended to have a slow or a quick pitch. Thus, if the screw is to advance one inch in a complete revolution, and the shaft be ten inches long, the length of the parallel straight edges must be ten circumferences of the shaft. A third straight edge is now fixed diagonally between the other two from end to end, and its angle in that position is precisely that of the thread proposed to be made. In the upper edge of this cross-piece a groove has been cut, and a strip of Bristol board inserted, which is smeared with printers' ink. The smooth shaft is now made to roll evenly between the parallel uprights, over the diagonal, which prints upon it a regular spiral line, which the workman can follow with his tools. As the mechanical arts advanced it became easy to cut a correct thread in a lathe, without any guides or previous marking, the only requirements being that the cutter should be fixed at the proper angle, and that its rectilinear motion along the shaft should bear the same relation to its revolution as the pitch of the thread does to its circumference. Beautiful screw-cutting lathes are now constructed, in which, by the substitution of wheels of different radii, these relative motions can be so adjusted as to cut threads of any pitch upon shafts of almost any size.

From screws of moderate dimensions plates or dies can be formed, which will in turn cut other screws, and so on, *ad infinitum.* The way in which an interior screw can be made is by converting the original screw into a tap, which may be effected in various ways. It may be done by filing down the point of the screw into a taper square, leaving just a small portion of the thread upon the corners. This leaves obtuse angles, which are not of much use for cutting, but which serve well enough for some kinds of work. If it is filed of a triangular shape, the angles will have more cutting power; but they are still too obtuse to take out the substance of the metal. Or the tap may be filed away to a half-circle, in which case a radial angle is obtained, the sharpest that is ordinarily consistent with safety. Generally, taps are in succession used consisting of all these various forms, or with the addition of others nicked across the thread, the first having the threads blunted or left shallow, and the later ones coming up gradually to a sharp and perfect worm. The metal to be operated upon is held firmly in a vice or other machine, and the taps, fixed in a wrench of some kind, are worked backwards and forwards until the interior screw is a reverse fac-simile of the exterior one, plenty of oil being used to facilitate the process. If the whole substance of the metal were cut out from the hollows of the thread of the interior screw, the hole made to receive the tap in the first instance should be exactly the diameter of the inferior shaft, *i.e.*, the external screw stripped of its thread; but as part of the worm has to be formed by compression, and as some portion of the solid metal will be forced into the hollows of the tap, the hole must be made a trifle larger to allow of it. It is from neglect of these precautions that workmen get what is called a "slip-screw," viz., one in which the threads do not bite, and the screw turns round in its receptacle; if the hole has been bored too small the tap will not enter readily, or progress in proportion to its work, and blurs or strips the thread as it makes it; while if it be bored too large the thread made is too shallow, and is mainly formed by the burr of the metal, which will have no holding power. Pins with external screws are made with screw-plates, or dies, in the reverse manner to that just described, a portion of the thread being cut away to form a cutting or compressing surface, and a series, gradually deepening, being generally used. Dies are in two, three, or more pieces, being fixed in stocks, and tightened up with screws as the work advances. It need scarcely be remarked that the cutting instrument, whichever it may be, is hard, and the metal to be operated upon is soft. Innumerable are the uses for metal screws, from the minute pins, scarcely visible to the naked eye, which are used in watch-making, to the massive bolts which hold together the parts of our largest men-of-war.

Wood screws, by which are meant iron screws to screw into wood, are made in immense quantities, and are daily coming into more general use as a substitute for nails. In some parts of Scotland they are called "screw-nails," and it is worthy of remark that the screwed pins used in military small-arms are still, in the antiquated phraseology of the War Office, called "nails." Wood screws used to be made by a process which was primitive enough. The blanks were forged by the nail-makers, and resembled that species of nail called "counter-clout," with a blunt end. The transverse nick, or slit, was cut by a hand-saw in a vice, and the worm was filed laboriously out by hand. Later on they were wormed by means of a simple hand machine constructed as follows:—A spindle, with a "chuck" to hold the screw, worked in a frame fixed upon a bench, the back part being fitted with a winch. In front were a pair of cutting dies, upper and lower, the lower one being a fixture, and the other lying upon it heavily weighted. By means of a lever pressed down by the foot, the workman raised the upper die a little to allow the point of the screw to enter, and then, releasing the weight, turned his winch backwards and forwards until the thread was cut deep enough. The work, though very hard, was frequently performed by women, who bore the contemptuous designation of "screw-girders."

About the year 1849 machinery for making screws began to be extensively worked by steam power. It was the invention of a German, named Colbert, a clock-maker, and, compared with the clumsy methods formerly in use, must have been regarded as a remarkable step in advance. The screw-blanks were now made from iron wire, drawn of the required thickness, and cut off from the coil by a machine, which at the same time punched up the end to form the head. The half-formed screws were then turned one by one in a lathe, and cutters of the required form finished off the heads neatly. The next process was to nick the heads, which was also done by a machine. There were many different forms of nicking machines in use at various manufactories; but in principle they did not differ greatly, and the following description may serve to convey an idea of their generic type:—A small iron barrel or cylinder revolved slowly, overhung by a series of fine-cut circular saws, which revolved very rapidly, the motion of the saws and the barrel being in opposite directions. The surface of the barrel was pierced with a number of small holes, in lines running round the circumference immediately under the saws. The screw-blanks were fed into the holes, either by hand or by a self-acting feeding machine; and as they were carried round by the cylinder each head came under a saw, and was nicked across the centre, the blanks falling out afterwards by their own weight. They were then taken to the worming machine, which was thus constructed:—In front were a pair of holding clamps, which could be opened by the touch of a lever, and which gripped the head of the screw tightly, being assisted thereto by a small interior chisel which entered the slit. The driving-band being now slipped from the loose pulley to the tight one, the screw-shaft began to revolve, and at the same instant two other actions of the machine were brought into play. The spindle which carried the blank was furnished at its hinder end with a regulating screw the size and pitch of the one intended to be cut, and a nut being engaged with this carried the spindle forward at the same time it was revolving. Simultaneously, a cutting instrument came into contact with the shaft of the screw, and cut upon it a worm identical with that on the regulating screw behind. The machine having a reversible motion, this process was continued backwards and forwards, until the thread was perfect.

The screws made by this machinery were immensely superior to those formed in the old-fashioned compressing dies, which could not make a thread of sufficient depth, and a little force would suffice to "draw" them if the wood were at all soft. Still, the new screws were defective, inasmuch as they were not pointed or gimlet-ended, and, consequently, would not enter readily; and there was a burr left at the hinder end of the thread which "ragged" the wood. A beautiful screw was introduced and patented by Mr. Nettlefold, in which all these defects were avoided, and many new advantages secured. The shaft was tapering and pointed at the end; the thread was deep and bold, the under side having as great an inclination as could be given to it, while the upper side was almost flat. This enabled the screw to penetrate the wood easily, and at the same time to resist almost any force tending to draw it out.

The screw-making plant just described has been altogether

superseded by machinery introduced into this country from the United States about twenty years ago. In the "Patent Records" of that time we find the following description in a specification lodged by a firm of manufacturers from Rhode Island:—"This invention consists of a peculiar arrangement or combination of parts into a machine for cutting wood screws, for which purpose a series of holders or revolving spindles, suitable for holding revolving screw-blanks, are used. These spindles or holders are placed and revolve at a tangent to the periphery of a circulating rotating tool, which carries numerous cutters, and by reason of there being a cam or guiding track for the cutters, they are engaged as they come opposite a screw-blank, to be moved outwards, and to make a cut across the revolving screw-blank. Each cutter, after making its cut, is moved back out of action till it comes to the next screw-blank; it is then moved outwards to make its cut, and so on continually; the succeeding cutter being protruded further out than the preceding one, cuts more and more deeply into the screw-blank. The cutting point or edge of each of the succeeding cutters is wider than the preceding one, and therefore cuts wider and wider as well as deeper and deeper into the screw-blank carried by the holders. It will be evident that by thus using several cutters in the same rotating tool, several revolving holders may be used, each carrying a screw-blank in the presence of the rotating tool, and have the separate cutters act in succession on each screw-blank."

Here for the present we must leave this interesting subject, but in a future paper we shall describe the effect which the introduction of the American machinery had on the screw trade, and give additional particulars respecting this important manufacture.

NOTABLE INVENTIONS AND INVENTORS.

XXXIV.—CHLOROFORM (*continued*).

BY JOHN TIMBS.

The action of ether, and the best mode of administering its vapour, was investigated by Dr. John Snow, who in September, 1849, published a work on "The Inhalation of the Vapour of Ether." This subject was investigated with great success in Edinburgh, and led to the discovery by Dr. Simpson, of that city, of chloroform, a terchloride of formyle, which acted more speedily and effectively. From this time chloroform became more generally employed for the production of artificial anæsthesia. The general effects of chloroform resemble closely those of ether. It is a more potent remedy, and produces anæsthesia more rapidly and certainly than ether.

Chloroform was first discovered and described at nearly the same time by Soubeiran, 1831, and Liebig, 1832; its composition was first accurately ascertained by the distinguished French chemist Dumas, in 1835. It had previously been used by some practitioners internally. Guillot prescribed it as an anti-spasmodic in asthma, in small doses, and diluted 100 times. But no person, Dr. Simpson believes, had used it by inhalation, or discovered its remarkable anæsthetic properties, till the date of his own experiments. It is a dense, limpid, colourless liquid, readily evaporating, and possessing an agreeable, fragrant, fruit-like odour, and a saccharine, pleasant taste.

In March, 1847, M. Flourens caused animals to inhale pure chloroform, which rendered them insensible; but, believing it to be a dangerous agent, he did not think of commending it for the prevention of human pain. Dr. Chapman says, "Anæsthetic agents should only be administered by those who possess knowledge and experience of their properties. The very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death; only those agents which are capable of leading us along this solemn path, and which having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain."

As an inhaled anæsthetic agent, chloroform possesses over sulphuric ether the following advantages:—1. A greatly less quantity of chloroform than of ether is requisite to produce the anæsthetic effect. 2. Its action is much more rapid and complete, and generally more persistent. 3. The inhalation and influence of chloroform are far more agreeable and pleasant than those of ether. 4. The use of chloroform is less expensive than that of ether. 5. Its perfume is not unpleasant, nor does it exhale in a disagreeable form from the lungs of the patient, as generally happens with sulphuric ether. 6. Being required in much less quantity, it is much more portable and transmissible than sulphuric ether. 7. No special kind of inhaler or instrument is necessary for its exhibition. A little of the liquid diffused upon the interior of a hollow-shaped sponge, or on a pocket-handkerchief, or a piece of linen or paper, or held over the mouth and nostrils, so as to be fully inhaled, generally suffices, in about a minute or two, to produce the desired effect.

"The following is the chemical constitution of chloroform:—Formyle is the hypothetical radical of formic acid, first discovered in the red ant (*Formica rufa*), and hence named. It is now obtained from starch, sugar, and, indeed, from most other vegetable substances. A series of chlorides of formyle are produced when the hypochlorites are brought to act on the chloride, oxide, and hydrated oxide of methyle (pyrolixic or wood spirit). In the same way, as formic acid may be artificially procured from substances which do not contain formyle ready formed, so also are the chlorides of this radical capable of being procured from substances which do not originally contain it.

"Chloroform, chloroformyle, or the perchloride of formyle, may be made and obtained artificially by various processes—as by making milk of lime, or an aqueous solution of caustic alkali act upon chloral—by distilling alcohol, pyroxylic spirit, or acetone, with chloride of lime—by leading a stream of chlorine gas into a solution of caustic potass in spirits of wine, etc. The resulting perchloride of formyle consists of two atoms of carbon, one of hydrogen, and three of chlorine.

"It is now well ascertained that three compound chemical bodies possess, when inhaled into the lungs, the power of superinducing a state of anæsthesia, or insensibility to pain in surgical operations, etc.—namely, nitrous oxide, sulphuric ether, and perchloride of formyle. These agents are entirely different from each other in their chemical constitution; hence their elementary composition affords no apparent clue to the explanation of their anæsthetic properties." (Dr., afterwards Sir James Simpson.)

Dumas, in his examination of chloroform, showed that if for the three equivalents of oxygen three equivalents of chlorine were substituted, the product would be a *terchloride of formyle*. Such being Dumas's ingenious view of the constitution of this important substance, he very properly named it *chloroform*.

This substance is prepared, according to the Pharmacopeia of the London College of Physicians, as follows:—"Take of chlorinated lime, 4lb.; rectified spirit, 0ss.; water, 0x.; chloride of calcium, broken into pieces, ℥j. Put the chlorinated lime, first mixed with water, into a retort, and then add the spirit, so that the mixture may fill only a third part of the retort. It is then heated in a sand-bath, and as soon as ebullition begins, the heat is withdrawn. The liquid is then distilled into a glass receiver. A quart of water is then added to the distilled liquid, and well shaken. The heavier portion, which subsides, is then separated, and the chloride of calcium added to it, and frequently shaken for an hour. The liquid, which is the chloroform, is again distilled from a glass retort into a glass receiver. It is a transparent, colourless liquid, having a specific gravity of 1·48. It has a fragrant, apple-like smell, and a slightly acid and sweet taste. It is soluble in alcohol and ether, but requires 2,000 parts of water for its solution. It dissolves camphor, Indian rubber, wax, and resins. It is not inflamable. This substance is sometimes given internally, in doses of from five to ten minims, and acts as a stimulant, sedative, and anti-spasmodic and anæsthetic."

Sir James Simpson's special application of the new remedy in child-birth must next be noticed. In early days it was believed that the period of insensibility could not be prolonged with safety. This erroneous belief was speedily dispelled by Simpson, whose most profound compassion had been excited by the sufferings of women in child-birth. These sufferings he determined, if it were possible, to relieve, and on the 19th of January, 1847, he, for the first time, employed ether for this purpose, and with complete success, in a case of unusual difficulty and severity. Others of like kind followed, and in March he published his first memoirs on the subject. From this time his use of ether in natural labour commenced, and in November, 1847, he announced that he had employed it, "with few and rare exceptions," for every patient he had attended.

"And I have no doubt whatever," he adds, "that some years hence the practice will be general. Obstetricians may oppose it, but I believe our patients themselves will force the use of it on the profession. I have never had the pleasure of watching over a series of better and more rapid recoveries, nor once witnessed any disagreeable result follow to mother or child, while I have now seen an immense amount of maternal pain and agony saved by its employment. And I most conscientiously believe that the proud mission of the physician is distinctly twofold—namely, to alleviate human suffering as well as to preserve human life."

"While announcing these successes, Simpson had, nevertheless, been struck by certain inconveniences connected with the use of ether, and by the idea that its anæsthetic properties were probably common to many substances of a similar kind, some of which might offer still greater advantages. He made inquiry among his chemical friends with regard to such agents, and selected several for experiments, in which he was zealously seconded by his assistants, Dr. Keith and Dr. Duncan. In such experiments it was Simpson's custom first to test the safety of a new vapour by inhaling it himself, and then to observe its effects by administering it to his assistants. Mr. Waldie had suggested that the perchloride of formyle might be worthy of a trial; and in the application of this agent, soon and since universally known as chloroform, Dr. Simpson made the great discovery of his life. His work was very materially promoted by the highest personage in the land, who, having sent for him and heard his opinions, and the results of his experience, retained Dr. Snow to officiate as chloroformist at her then pending accouchement. One Edinburgh damsel, when the example set by Her Majesty became known, is said to have expressed much surprise that the new pain-destroyer 'should hae gotten sae far sooth as London;' but the example, nevertheless, had great weight, and every fresh convert served to spread conviction in ever-widening circles. For many years the use of chloroform has been as customary with the accoucheur as with the surgeon, and it would now be more remarkable that it should be withheld than it should be administered." (Review of Sir James Y. Simpson's Work, *Times*, May, 1872.)

The physiological effects of the vapours of ether and chloroform are classified by Professor Brande in five definite and progressive stages. 1. In the first stage, which is transient, the patient is exhilarated, but conscious of what is passing before him, able to direct the motions of his limbs, and sensitive to pain. 2. In the second stage, mental functions as well as voluntary movements are performed, but irregularly. The patient knows not where he is, and is generally, but not always, ready to do what he is directed. This, according to Dr. Snow, who has investigated the whole subject with great accuracy, is the stage of dreams. 3. It is in the third stage that the mental functions and voluntary movements become dormant, although external impressions may here produce involuntary action. Any pain inflicted in this stage might call forth a groan, but it would be expressed by articulate words. 4. In the fourth stage there is no movement besides that occasioned by the snoring of the patient, which indicates him to be in a condition of absolute insensibility. 5. In the fifth stage, which has been witnessed only in the inferior animals, the breathing becomes laboured and irregular, involuntary and voluntary muscles are alike powerless, respiration and circulation successively cease, and death ensues.

The fatal effects of chloroform depend not upon peculiarities in individual constitution, but upon faults in the mode of administration.

Dr. Phipson states of the action of chloroform: "In the human body exist different systems of nerves, and the art of producing anæsthesia consists in allowing one system to work as usual, while the other systems are under the influence of sleep. The nerves of motion and sensibility are made to sleep, while the nerves of organic life continue their functions. We are now enabled to appreciate these wonderful discoveries, and to admire the marvellous arrangement of the nervous system. The problem of depriving man of sensibility and motion without impeding respiration, circulation, digestion, or, in other terms, of depriving him of the means of his faculty of moving and of feeling pain without depriving him of life, has been solved. During anæsthesia (the sleep of chloroform) man lives like a plant: his animal functions are taken from him for a time."

Dr. Chapman considers that we have no expectation that any agent of anæsthesia will ever be discovered which may be used by ignorant, inexperienced, or incautious persons. We may again repeat that "the very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death; and only those agents which are capable of leading us along this solemn path, and which having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain." This consideration should teach us that these beneficial agents, like that of fire, cannot be recklessly used with impunity, and that only those who possess knowledge and experience of their properties and modes of action are justified in administering them.

Lastly, chloroform has been extensively used in every hospital in Europe. It was the greatest boon to our poor wounded in the Crimea and India. The exhaustion of the stock of chloroform in Lucknow was one of the greatest calamities in that fearful siege. No fatal case occurred from its frequent use in the Crimea. Dr. Snow could ascertain but fifty fatal cases throughout the world which could fairly be attributed to chloroform during ten years. For several years before his death he made about £1,000 a year for administering chloroform in private practice. He met with but one fatal case among the many thousands to whom he administered chloroform. The fatal effect is by paralysing the heart; but the chance of this result, with due care, is very small; indeed, it has been compared with the chance of a fatal railway accident.

WEAPONS OF WAR.—XIV.

BY AN OFFICER OF THE ROYAL ARTILLERY.

RIFLED PROJECTILES.

In immediate connection with the preceding chapter (Vol. II. page 391), is the subject of rifled projectiles. The subject is not only a very important but a very wide one—so wide, indeed, that we despair of doing justice to it within the limits which must necessarily be observed in a series of papers of this description. As to its importance, that must be evident to the most superficial observer. A gun, after all, is only the means of application of its projectile. It is the motive power of the machine, not the machine itself—it is the projectile which strikes and does the work. Therefore, upon the suitability of the projectile for the end for which it is designed, depends ultimately the value of the gun. Even the "Woolwich infant" firing snowballs, or discharging cast-iron shot against an armour-plated vessel, would accomplish nothing. And so the ultimate virtue—the effective value—of the gun resides in the projectile, by which the destruction to life or material is wrought.

To attempt even to enumerate within a single chapter the varieties of rifled projectiles in the service would be vain. In the case of smooth-bore projectiles, where the sphere is the only practicable form,* and where there are no changes to be rung on modes of rifling, the classification is comparatively easy. But with rifled projectiles, we have not only the shot or the shell, each with its varieties, but we have of each the breech-loading and the muzzle-loading type, as well as infinite varieties of form and proportion.

Breech-loading projectiles, although they exist in great numbers in our service, are gradually disappearing before the more simple, less expensive, but not less efficient, muzzle-loading projectiles. As has been already explained in preceding chapters, the breech-loading projectiles in use in the English service are of a construction suggested by Sir William Armstrong—viz., an iron projectile covered with a leaden coating, slightly larger than the bore, which on the explosion of the charge becomes forced into the shallow grooves of the rifling, thus communicating the required rotatory motion to the shot. It should be clearly understood that the lead coating is merely a means of spinning the projectile. It is not an essential or integral part of the projectile—that is to say, breech-loading projectiles can be spun by other means than a lead coating, although this lead coating may, and does in fact, cover an infinite variety of constructions of projectile. Some of the salient advantages and disadvantages of this *système forcé* have already been

* Except in the case of such exceptional projectiles as the smoke ball and Manby's shot.

mentioned in a former chapter. To discuss this branch of the question as it merits is impossible here. Suffice it to say that a series of experiments, carried out almost without intermission, and by all sorts of committees, since 1858, has ultimately resulted in the decided preference of studded to lead-coated projectiles for our service. Gradually projectiles of the latter type will disappear; and although other nations, such as the Germans, appear to cling to them, it is not improbable that fuller experimental inquiry will tend to the same conclusions as those at which we have arrived. The normal type of rifled projectile in our service is now a muzzle-loader, the spin being given to the projectile by means of studs, set on so as to suit either a uniform or an "increasing" spiral, according to the rifling of the gun. The material of the studs, their size and strength, are proportioned to the strain which they will have to bear. They are made either of copper or of gun metal (copper and tin), and are attached to the projectiles by means of "undercutting."

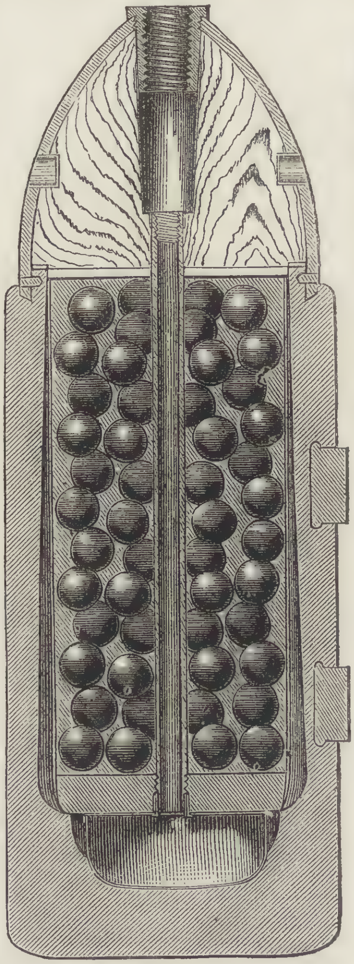


Fig. 1.—RIFLED SHRAPNEL SHELL (SECTION).

Passing from the means of spinning the projectile to the projectile itself, we find several varieties, according to the nature of the work required to be accomplished. The simplest form of rifled projectile is the shot. Of this there are two or three principal types — the ordinary solid shot, the case-shot, and the Palliser shot. The ordinary solid shot, which is an elongated cylindro-conoidal projectile of cast iron, about $2\frac{1}{2}$ calibres in length, is comparatively little used now. It is of no use against an armour-plated vessel, while against a wooden vessel, or against inflammable material of any description, a shell is much more effective. Therefore ordinary solid shot are used chiefly for practice, as being the cheapest form of rifled projectile available for the purpose. The case-shot differ from those used with smooth-bore guns only in detail. They are provided with segmental zinc linings, to prevent the crushing up of the case into the grooves of the rifling. Some patterns have coal dust between the balls, others sand and clay, to prevent the agglomeration of the balls, or their loss of form on discharge. For short ranges against the *personnel* of an enemy a case-shot is the most effective projectile known to artillerists. But this effect, on account of the lightness of the balls, and their rapid dispersion, is soon lost, and then the shrapnel shell comes into play. Of the smooth-bore shrapnel we have already spoken; of the rifled shrapnel we shall speak directly.

A more important projectile for the larger rifled guns is the Palliser shot. This may be considered the projectile *par excellence* of our heavier or plate-piercing guns. The Palliser shot is called after its inventor, Major William Palliser. This distinguished officer, who, though not an artilleryman, has done much to improve our artillery material, has the merit of having, in his shot, as in other of his inventions, struck out an original line of his own. At the time when Major Palliser introduced his shot efforts were being made to find some material suitable for piercing iron plates. The choice seemed to lie between a tough steel and a hard wrought iron. It was generally thought at that time that toughness was one of the elements necessary to success. And this combination of hardness and toughness was exceedingly difficult to obtain, at anything like a reasonable cost and with uniformity. Major Palliser may lay claim to originating the idea that toughness was not necessary at all. All that was wanted, he said, was hardness—hardness intense and unvarying; and this he found, allied with cheapness, in ordinary "chilled" iron—in iron, that is to say, which had been cast in an iron mould or "chill"* instead of in sand. Great care was necessary in the selection of the iron, and innumerable experiments were made on this point in the Royal Laboratory. Indeed, even Major Palliser's genius would have availed little without the indefatigable and zealous co-operation of the able manager of that department, Mr. Davidson, who, under Colonel Boxer, laboured for years at this important subject. At last a suitable iron was found, and the appliances for casting these shot were brought, under Mr. Davidson's guidance, to great perfection. It must not be supposed, however, that hardness is the only feature in Major Palliser's projectiles. On the contrary, that hardness had to be associated with a particular form of shot to produce any useful results. A flat-headed or an obtuse-headed chilled shot shivers to pieces like so much glass on the side of an iron plate. Major Palliser had got the hardness, but with it he had got brittleness. How was this brittleness to be neutralised or eliminated? Up to that time it had been supposed that it could be got rid of only by introducing some toughening element. But, as we have stated, Major Palliser chose another course. He argued that if he could make his shot of such a form that it would convert the shock of impact into a gradually increasing pressure, he would neutralise the brittleness. He applied this principle by adopting an ogival head, with a radius of from $1\frac{1}{4}$ to $1\frac{1}{2}$.

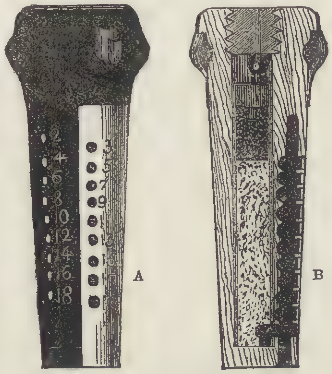


Fig. 2.—BOXER'S NINE SECONDS' TIME FUSE.
A, fuse; B, section of fuse.

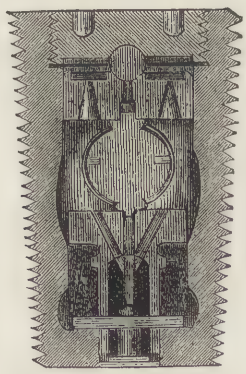


Fig. 3.—PETTMAN'S PERCUSSION FUSE.

Thus the Palliser projectile is not merely a chilled iron projectile—for that would constitute in itself no novelty, although chilled iron had never before been applied to the penetration of armour plates—nor is it merely a sharp-pointed ogival-headed projectile. It is a combination of material and form, and in this combination the virtue of the discovery resides. Indeed, we believe that Major Palliser lays no particular stress on the chilling, except as a convenient and inexpensive means to an end. Any hard, white metal shot, made

* At one time *all* shot were cast in this way.

with a Palliser head, would answer the purpose; in fact, some successful experiments have been made with white iron shot of the Palliser form, the shot having been cast in sand and not in chill. A few words should here be said as to the meaning and effect of chilling. The meaning of chilling is casting iron in an iron mould instead of in sand. The result of such casting is that the metal, instead of being slowly cooled, is quickly cooled, or "chilled," by being brought into contact with a material of high conducting power. In proportion as the cooling is slowly or quickly effected so does the separation of the carbon from the iron proceed more or less completely, quick cooling being unfavourable to such separation. In proportion as the separation is complete, so will the iron assume a greyer or darker tint, in consequence of the mechanical diffusion through it of the particles of carbon in the form of graphite; while, conversely, in proportion as the separation is incomplete—in other words, in proportion as the cooling is rapid—so will the iron assume a more or less brilliantly white appearance, the carbon being held in chemical combination with the iron. White iron, as compared with grey iron, is intensely hard and brittle; and Major Palliser's process consists in converting into this hard and brittle material iron which is primarily neither one nor the other—viz., grey or mottled iron. The result, when cast into ogival-headed projectiles, is extraordinarily effective. At comparatively small cost a shot is obtained with which no steel projectile has yet been able to compete, and the effect of these shots breaking up after they have penetrated, and entering the vessel in a shower of splinters, is equal to that of a shell or of a case. At first Palliser projectiles were cast entirely in chill, but it was subsequently found desirable to cast the bodies in sand (so as to avoid exposing too brittle a portion to the shock of discharge), and the head only in chill (so as to obtain the necessary penetrative results). Palliser shell differ from Palliser shot only in having a powder-chamber for the bursting charge in the centre. For manufacturing reasons, which need not be here entered into, the shot are now cast with a small cylindrical hollow or "core" in the centre, but the shells have a much larger hollow, and contain from 2 to 15 lb. of powder, according to their size. The explosion of the powder is effected by the breaking up of the shell on impact on iron plates, no fuse being required. This effects a considerable simplification in the use of these projectiles. The Palliser shell is shown in Fig. 5.

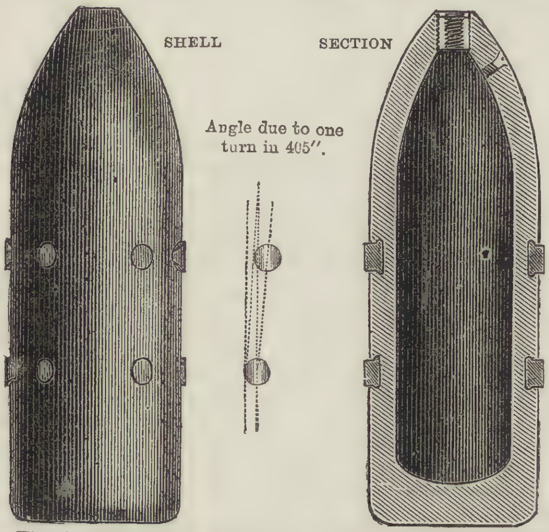


Fig. 4.—NINE-INCH MUZZLE-LOADING COMMON RIFLED SHELL.

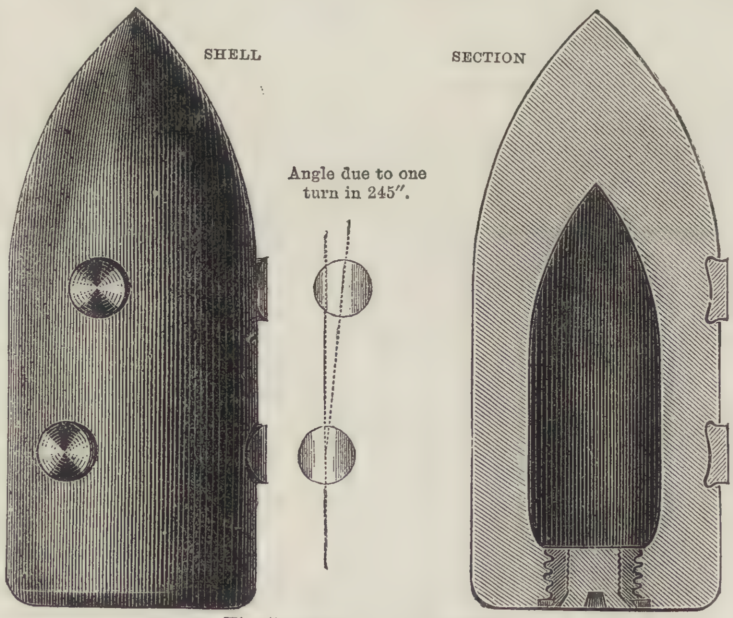


Fig. 5.—THE PALLISER SHELL.

In addition to Palliser shell and shot, our rifled guns fire common and shrapnel shell, and some of the smaller natures fire segment shell, which latter, however, are gradually giving place to shrapnel. A few remarks must now be made on each of these projectiles. The common rifled shell (Fig. 4) is a cylindro-conoidal projectile of cast iron, which is exploded by means of a fuse (either "time" or "percussion") fitted into its apex. The length of the 12-inch shell is about 30 inches, that of the 7-inch about 22 inches, or, roughly, from $2\frac{1}{2}$ to $2\frac{3}{4}$ times their calibre. In the case of the 10-inch shell the proportion is greater, that projectile being 32 inches (or over three times its diameter) in length. The capacity of some of the larger shells is enormous. Thus, the 12-inch shell takes no less than 35 lb. of powder, the 10-inch shell takes 26 lb., the 9-inch 18 lb., the 8-inch 13 lb., and the 7-inch 8 lb. For use at short ranges the 7-inch gun is also provided with a "double" shell—*i.e.*, a longer projectile of increased capacity. This shell contains nearly 13 lb. of powder. It is instructive, as conveying an idea of the enormous increase of shell power due to the use of elongated projectiles, to compare the above-mentioned bursting charges with those of the old smooth-bore spherical shell. Thus—

	Rifled.	*Smooth.*
13-inch,	32 lb.	10 lb.
10-inch,	26 lb.	5 lb.
8-inch,	13 lb.	$2\frac{3}{4}$ lb.

For use against wooden ships one rifled shell would be as powerful as many smooth-bore shells; and when the greater range and accuracy of the former are taken into consideration, it will be evident that the importance of the introduction of rifled projectiles as a means of destruction can hardly be overrated. They deal destruction at greater distances, in a larger degree, and with increased certainty. Against iron-plated vessels common shells have comparatively little value, on account of their low penetrative power. But if the ship is only very lightly plated, or not plated at all, one rifled common shell may cause her destruction. The moral effect of the explosion of from 20 to 30 lb. of powder inside a vessel is incalculable. We believe that it is a fact that the defeat of the *Alabama* by the *Kearsage* was practically completed by a single shell. In the smaller guns common shells are very useful against an enemy's earthworks, houses, and material generally. By some nations (as the Germans) they are largely, almost exclusively, used against his *personnel*. But such a use seems hardly suitable for common shell; at any rate, greater destruction can be effected in an enemy's ranks by means of shrapnel and segment, and the Germans have, since the late war, taken

steps to introduce shells of the shrapnel—or, as we should say, *man-killing*—type.

Before speaking of the rifled shrapnel shell, it may be well to explain the construction of the segment shell. This projectile, which is now gradually dying out of our service, was the invention of Sir William Armstrong. It consists of a thin cast-iron shell, inside which are built up a number of rows of segmental pieces of iron, like stones in the arch of a bridge, a cylindrical cavity being left up the centre for the bursting charge. This construction gives the projectile very great strength to resist external pressure, whether from the shock of discharge or the shock of impact, or otherwise, while it enables the shell to be opened by a small bursting charge. The internal strength is to the external as the internal strength of an arch is to its external strength. Then, when the shell is opened by the bursting charge, the segments form so many separate missiles, of a formidable and destructive character. In the course of the trials at Dartmoor, in 1869, no less than 1,194 hits of all sorts were obtained with 15 rounds of 12-pounder segments fired against a column of six rows of infantry targets. This is, we believe, the greatest effect ever obtained with shells of this class, and to this extent it is exceptional; but on many other occasions the segment shell has greatly distinguished itself. Long series of experiments have, however, gone to show that such distinction is likely to be achieved only when the conditions of the practice are peculiarly or accidentally favourable. Thus, with a known range, at a column of troops, with plenty of time, with ground especially favourable for percussion fuses, and with good men to lay the gun, excellent results may be obtained. But such a combination of favouring circumstances is rare, and what is wanted is a shell which will give good average effects under the ordinary conditions of service. This the segment does not do, and cannot do, for two very good reasons:—(1) the bursting powder being in the centre of the shell, it necessarily causes great lateral dispersion of the segments in opening the bullets; (2) the segments being made of iron, which, as compared with lead, has a low specific gravity, and being of an irregular form, are not favourable to sustained flight and velocity. These two conditions result in the effect of the segment shell being exceedingly local. A good shell bursting at the foot of a body of men will produce tremendous effects; but let the point of rupture be twenty or thirty yards from the column, and the effect will be at once enormously reduced.

These defects have been remedied in Colonel Boxer's rifled shrapnel shell, which is an application to the rifled projectile of the construction adopted by him in the diaphragm shrapnel. The accompanying section (Fig. 1) of the rifled shrapnel explains itself. It will be observed that the powder is situated *behind* the missile matter, with which the shell is filled, and which consists of spherical bullets. The size, weight, and number of these bullets varies, of course, with the calibre of the shell. Thus, the 7-inch shrapnel contains 227 8 oz. balls; the 8-inch contains 376 10 oz. balls; and the 9-inch, 564 12 oz. balls. The 16-pounder shell contains 63 large bullets and 56 small ones; the 12-pounder breech-loading shrapnel contains 42 bullets, 18 to the pound; and the 9-pounder, 21 of the same bullets. From time to time, as the patterns of the shell alter, these numbers are slightly varied. The above figures are, therefore, given only as exhibiting approximately the capacity of shells of this class. As *man-killing* projectiles, the effect of the rifled shrapnel shell is tremendous. It is intended to be opened at a certain distance in front of the object to be fired at, when the bursting charge, ripping up the sides of the shell, liberates the bullets, which proceed onward in a curved cone, the apex of which is at the point of explosion. On one occasion, at Dartmoor, the 12-pounder shrapnel, firing nine effective rounds, gave 652 hits of all sorts, of which 374 were "throughs." In the recent trials against the German gun at Shoeburyness, the shrapnel shell more than once greatly distinguished itself. For example, out of 5 rounds fired at 800 yards with percussion fuses, the effects were on one occasion no less than 103 hits per round, against 33 hits with the German common shell. At 1,500 or 2,000 yards the shrapnel gave from 30 to 40 hits per round. In the course of the 16-pounder trials, the following results have been obtained. At 1,000 yards, against two rows of targets, 67 hits per round; at 1,500 yards, 82 hits per round; at 2,000 yards, 70 hits per round. These are prodigious effects, particularly when it is considered that to produce them it is not necessary to make a good shot every time—that is to say, the shell may be burst from 50 to 150 yards short of the object with excellent effect, thus giving a large margin of permissible error in the laying of the gun, and in the preparing and burning of the fuse. And the great advantage of the shrapnel over the segment is, that it can be used with excellent effect with a "time" fuse, as well as with a "percussion" fuse—in other words, it is independent of the character of the ground over which it may be fired; whereas the segment, requiring an accuracy of action not to be obtained in the field with time fuses, can be effectively used only with percussion fuses, and is thus useless over boggy, or very broken, or very soft ground. To discuss the subject of shrapnel *versus* segment as it deserves, would occupy far more space than can here be allotted to it. What we have said as to the relative merits and performances of the two, will show that both shells possess considerable merit, the shrapnel having the advantage in general utility and effect.

With these remarks we conclude our hurried and imperfect sketch of rifled projectiles. But before closing this chapter, we should wish to make a few remarks upon the subject of fuses for shells. In the case of Palliser shells no fuse is required, the heat generated on impact being sufficient to fire the powder. But with other shells a fuse is necessary. There are two great classes of fuses, time and percussion (or concussion). The time-fuse is a contrivance for igniting the bursting charge of a shell (whether common, shrapnel, rifled, or smooth-bore) at any particular *time* after the shell leaves the muzzle of the gun. Various sorts of time fuses have been proposed, and of these varieties several have found a temporary footing in our service. The typical time-fuse, however, is the Boxer (Fig. 2), in which a cylindrical column of fuse composition (which burns at the rate of 1 inch in 5 seconds) is disposed vertically in a truncated wooden cone. By means of horizontal side holes, placed one-tenth of an inch apart measuring vertically, the wood can be easily pierced at any required point, opening a vent for the burning composition, which instantaneously flashes down the vertical powder-channel. For example, supposing that the shell is required to burst $2\frac{1}{2}$ seconds after it leaves the muzzle, the side hole marked $\frac{5}{10}$ ($= \frac{1}{2}$ inch $=$ 5 half-seconds $= 2\frac{1}{2}$ seconds) would be bored through into the composition; the flame would come through when the composition had burnt down to that point, and would proceed by a flash down the powder-channel to the bursting charge of the shell. Breech-loading time-fuses are made on the same principle, with the addition of a detonating arrangement in the head for igniting them, this being necessary because the fuse cannot, as in the case of the muzzle-loader, be ignited by the flash of discharge.

Percussion fuses are of infinite variety, and great has been the expenditure, often fruitless, upon their production. They are intended to explode the shell on its striking an object, and without reference to its time of flight. One of these fuses, the Pettman, may be taken as a type (Fig. 3). In this fuse a small brass ball, coated with detonating composition, is enclosed between two supports, one of which rests upon a wire (and a lead cup), which is broken (and the cup is crushed) by the shock of discharge. The ball is thus liberated, and on impact is thrown violently against some part of the interior of the fuse and exploded. The flash passes at once to the bursting charge of the shell. By an ingenious arrangement in the head of the fuse, which our space does not permit us to describe, this fuse may be used for either rifled or smooth-bore projectiles, the conditions of which are different.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XIV.—SYSTEMATIC COLLECTIONS, ETC.

Details of Systematic Collection.—Practically, the "displayed" specimens in the public galleries and the "store specimens" in the adjoining studies would form one series. In 1862, Dr. J. E. Gray reported that he exhibited in zoological galleries 140,000 specimens, and that he had in store for the use of students (including under that term "experts" in zoology) 489,000 specimens, making a total of 629,000 specimens for the national illustration of zoology. This number included varieties and duplicates, but in the new museum "all specimens that are

*absolute duplicates** should be disposed of, as Thomas Bell very properly pointed out to the committee on the British Museum, and to that end should be kept in a separate department in the basement, for the purpose of exchange with dealers or private naturalists, or for replacing damaged specimens. Of late years, however, the question of the origin of species has made us regard duplicate specimens with an entirely different eye to what we did before, for many "varieties" which formerly would have been looked upon as mere duplicates have now become as important as "species." But a few years back the Museum was sadly deficient in specimens that were needed to prove or disprove Darwin's theories. On Professor Owen being applied to by a celebrated naturalist, in 1860, to assist him in procuring the specimens illustrative of the species and varieties of pigeons, he could not find more than twelve varieties of the most common domesticated pigeons, and three skeletons. The collection possessed specimens of the "tumbler," but not one of the common "pouter" pigeon, for at that time the series promised by Dr. Darwin to illustrate his work had not reached the Museum; and Professor Owen was forced to state, "As to showing you the varieties of species or any of the phenomena which would aid in getting at that mystery of mysteries, the origin of species, I am obliged with shame to say, I can show you none of them." But surely our country ought to possess specimens of everything that is known to naturalists, and expect in our national museum to find (at least in the future) all that is attainable.

Another point of the utmost importance connected with the systematic collection is that the skins, skeletons, spirit and histological preparations, models, eggs, nests, nidamental structures, and fossil species, at present widely scattered over the British Museum, should be amalgamated into one series. In regard to the amalgamation of the fossil with the recent species, very decided opinions have been expressed by Drs. Sclater, Wallace, and other eminent naturalists, including Professor Flower, who thus conveys the general feeling on this important question:—"If the construction of the new museum tends to perpetuate the present artificial distinction between extinct and recent species of animals, it will hinder instead of promote the progress of any general conception of the organic world as a whole, and will also impose unnecessary difficulties in working out the minute comparisons by which the affinities and gradations between the various units of which that world is composed are recognised."†

Professor Flower, in the same article, thus fully justifies the prevailing opinions I have advocated in these articles:—"We are only beginning to form any idea of the enormous numbers of specimens actually required to enable us to rest our generalisations relating to most zoological problems upon a firm basis, and of the importance of keeping these specimens in such a condition, and so placed, that they can be examined and compared with the greatest facility. Provision should, therefore, be made in the new museum for the great bulk of the collection being thus treated. It would be quite a mistake to suppose that they would then be shut up and put away, and that the public have no further concern in them, and ought not to be expected to pay for their accommodation. They would be in exactly the same circumstances as the books in a well-arranged library, and ought to be equally accessible under suitable regulations; and *there are thousands of people who will read with interest the conclusions that scientific men will draw from their study of them, who would never care to see, or if they did, never learn anything from, the specimens themselves.*"

Much greater care should be given to "setting up" the stuffed animals and mounted skeletons in an artistic manner than has hitherto been thought necessary in this country, though the educational importance is fully appreciated by the curators of the Stuttgart Museum, which Mr. Alexander Agassiz, after visiting all the great collections, regards as the most instructive museum in Europe. To this end the most artistic taxidermists should be secured—men who should be artists in the true sense of the word, and who could render the characteristic aspect and motion of the animals represented. Think of the common cat as a familiar illustration of the "characteristic motion" of animals: see how upright she stands on her paws, head erect, tail moving in graceful undulations, whiskers bristling, eyes looking straight forward; suddenly they flash with a brilliant phosphorescent emerald-green light, the fore part of the body is simultaneously depressed, the limbs from the paws to the elbows nearly touch the ground, the hind quarters are raised and the limbs thrown backwards, while the tail lashes from side to side with vicious fury; then how stealthily, with undulating back, she creeps forward, and with noiseless bound springs upon her prey, with talons till now sheathed, and with white, sharp, dagger-like teeth, crushes her victim in the dust, anon flings it in the air, plays with it, pats it tenderly with her cushioned but ruthless paws, till it suits her pleasure to give the *coup de grâce*. What taxidermist, unless deeply imbued with an artistic appreciation of his subject, could, with plastic touch, imbue the dead skin with any of the characteristic aspects here described; yet there are, or have been, such men who could blend artistic feeling with scientific truth, as Waterton of our own country, Verreaux of Paris, and the Stuttgart staff.*

The "deadly-lively" stuffed beasts that are yet too prevalent in our existing museums, do more harm than good among the class for whom they are chiefly intended—viz., the uninitiated in natural history. In our national museum, at least, they should be rendered as life-like as the taxidermist's skill will admit of; and we know what Waterton's fingers could effect, guided by a naturalist's appreciative feeling. Far more must also be done in rendering by wax modelling the soft parts of mollusks, tube-bearing worms, coral-forming animals, etc., in connection with their shells and hard parts; while many other groups, such as Hydrozoa, Actinea, Polyzoa, the Ascidians, Nudibranchiata, Vermes, Starfishes, etc., the flowers and fruit of plants, etc., could only be rendered with lifelike aspect by means of carefully-executed wax models. The embryological and anatomical character must often be represented by the same means; while the bones of unique specimens, whether of recent or fossil species, such as the Dodo, Mylodon, etc., might be rendered in counterpart by means of plaster models, that would be undistinguishable from the original specimens. Though, as a rule, wall-cases and floor-cases are best suited for the display of the vertebrate classes, and table-cases for the invertebrates, minerals, etc., no fixed rule should be laid down, but that sort of case should be selected which is best suited for the particular group to be arranged for public inspection. It may here be noted that Schlegel, the director of the extensive Netherlands National Zoological Museum, at Leyden, arranges each "family" in a separate case; and by the position and arrangement of the several links of the chain of Nature in natural sequence, imparts knowledge by that method of silent information which may be made of such educational value in any museum. The "life history groups" should include illustrations of the habits and mimetic† characters of animals.

The botanical collections allow of but limited display, as they mainly consist of specimens of plants and parts of plants, mounted on separate sheets of paper, which are laid upon each other like the leaves of an unbound book, and kept in the trays of small cabinets, which allow of their being arranged or rearranged in blocks, that form series which illustrate the systematic geographical or historical aspects of botany. Such portions are known as herbaria, and being from their nature unfitted for public display, are consequently kept in the studies for the use of working botanists. It is only the hard parts, such as the seeds, fruit, leaves, wood, or sections of woods, fossil species, models of plants, etc., that are suited for public inspection, which is the reason the botanical department makes so little display at the existing museum, though the herbaria is one of the finest and most extensive in the world. Still much more might be effected than has yet been attempted by the use

* It may here be noted that in rendering fossil forms, many specimens may, from their damaged condition, be required, to show by a group all the characters of one species. Such duplicates could not, for instance, be regarded as "absolute duplicates."

† *Nature*, May 26th, 1870.

* The members of this staff have published a work that should be better known to the curators of this country, viz., "Die Praxis der Naturgeschichte, Dermoplastik und Museologie, oder der Modelliren der Thiere und das Aufstellen und Erhalten von Naturaliensammlungen." Edited by Herr Martin, and published by Voigt, of Weimar.

† See Fig. 7, page 329, Vol. III., of THE TECHNICAL EDUCATOR for an example of this phenomenon.

of such *multum in parvo* screens as are shown in Fig. 26 (page 64), and by models of botanical type forms, when the natural object would lose its characteristic aspect and colours, if exposed to light, etc.

The public galleries should be devoted to the illustration of structural botany to the fullest extent practicable; the studies to the specific character of plants. Both Sir Charles Lyell and Professor John Phillips attest to the value of recent specimens for the studies of the palæophytologist, and that, without the aid of the national botanical collections, they could not have identified certain fossil species described in their geological works. The late Robert Brown made it a proviso in his will that his collection of fossil woods should only be given over to the trustees of the British Museum on the condition that it should "form part of the botanical *exhibition*, under charge of the Keeper of Botany;" and should they decline to accept it on this condition, it was to be handed over to the Edinburgh Museum! The mineralogical collection, besides the series of meteorites at present displayed, should include such a series of rock specimens as is described in Cotta's "Gesteinslehre," and a complete suite of crystal models, for both of which there is existing material at the British Museum, though not displayed for want of space. The geological collection should be arranged in stratagraphical order, with restorations of extinct forms such as Unger* and Waterhouse Hawkins have suggested, the latter as to individual forms, the former as to entire landscapes; including both plants and animals, and such accessories as would best convey to the popular mind the creative phases of our earth, while not forgetting the practical requirements of the working geologist.

The wall-space above the cases in the galleries should be utilised with diagrams, the subdivisions of classifications, and maps showing the geographical range of the species displayed on the shelves beneath; while in the stratagraphical gallery, geological should be combined with geographical mapping of the distribution of animal or vegetable life.

TECHNICAL DRAWING.—LXXXI.

DRAWING FOR CABINET-MAKERS.

OBJECT DRAWING.

The student is at this stage advised to work through the course of lessons on Object Drawing, commencing at page 3, Vol. II., of The Technical Educator. The examples there given will show him the application of the Perspective lessons, and he will thus be prepared to benefit by the following studies.

Fig. 622 is a sketch of a drawing-room chair, placed so that its sides are at different angles to the plane of the picture. In commencing this subject, sketch the general ground-plan on the principle shown in the drawing of the kitchen chair, observing that in this case the plan is not a square, the chair being wider in front than at the back.

The uprights of the back are, as in the perspective study alluded to, continuations of the back legs. The light is supposed to come from a point in front of the object and in the left side, and above it; thus, the left angle of the seat and the left-hand front leg receive the strongest light. The side which is in full shade is not visible in the present view; the seat, which is slightly rounded, receives in consequence a slight shade towards its distant edge. The student is advised to draw several chairs placed in different positions in relation to his eye and to the light.

Fig. 623.—This sketch represents a "Davenport," or small writing-desk, supported on a pedestal containing drawers, and by two spiral legs in the front.

In commencing this subject, draw the entire cubical block out of which the whole mass could be carved, regardless of legs or recess—drawing, in fact, the mere packing-case in which the object could be contained. When this has been done, draw the line giving the bottom of the desk on each of the two visible sides; and as of course these lines are in the object horizontal, forming as they do two of the edges of the bottom of the desk, and as they are parallel to the bottom line of the side, and to that which would connect the two legs in the front, they would converge to the same vanishing points as the two last mentioned.

Next sketch the front edge of the desk, which will also converge to the left-hand vanishing point, to which the line joining the two legs has been drawn, the rule being borne in mind that all lines which in the object are parallel to each other vanish in the same point. The two short perpendiculars for the ends of the front of the desk having been drawn, raise the distant perpendicular for the back of the desk, and draw a line to the left-hand vanishing point, this line, too, being of course parallel to the front edge. Now complete the desk by drawing the slanting edges, etc.

Draw the perpendicular indicating the width of the pedestal containing the drawers, and also the corresponding one in the distance, connecting these at the bottom by a line parallel to the front of the desk, and thus converging to the same point. The framing at the bottom is now to be drawn, the lines converging to the left-hand vanishing point.

The spiral legs must now occupy attention. For each of these a central perpendicular should be drawn, and a line on each side of it, between which the whole pillar is to be contained, observing that the distant one must be rendered slightly narrower than that in the immediate foreground. The oblique and curved lines giving the twisted appearance will be easily followed from the example.

The light is supposed to come from a point in front of the object, above it in height, and on the left side; the front therefore receives the light, the brightest being at the angle, and on the slanting surface of the desk. The whole of the distant side is covered with a shade, whilst a shadow is cast by the desk on to the front of the pedestal. The right side of the pillars too are shaded, a reflected light being seen at the edge. The cast-shadow on the pedestal, as well as that on the ground, must, it will be remembered, be darker than the shades.

Fig. 624.—This sketch represents a loo-table. The spectator is in this case supposed to be *sitting* nearly in front of the object. The method of drawing circles in perspective has been explained elsewhere, and it will therefore be understood that if the spectator were supposed to be *standing*, the point of sight would be higher, and the width of the ellipse representing the circle would consequently be greater, and that as the point of sight were lowered the breadth would decrease, until it became lost altogether; thus a circular disc, when placed immediately on a level with the eye, is seen only as a straight line.

In commencing this figure, draw a perpendicular line for the centre of the pillar, and a horizontal crossing it for the long diameter of the ellipse representing the top of the table, which should now be sketched, as well as the double line representing the edge and the framing around it. The pillar should next be drawn, and then the base. This is an equilateral triangle in perspective, its angles being cut off, and its sides curved inward. Care must be taken in drawing the distant side of this triangle, which should in the first instance be sketched as one continuous curve, although afterwards interrupted by the pillar which crosses it. The thickness of the base, and the feet on which it rests, should now be drawn.

The light comes from a point in front, but slightly towards the left of the object. It will be seen that as the curved surface presents no sharp edge to the light, there is no definite point at which the shade commences. The brightest light is at the part of the circular edge and frame nearest the light, and from this it gradually tones down into the darkest shade, slightly lightened at the distant portion by reflected light.

The cylindrical pillar is shaded in a similar manner, but over a great portion of this the shadow of the top of the table is cast, and falling from above on a cylindrical surface, its outline is a curve tending obliquely downwards. It must be impressed on the student, however, that unless a shade is bounded by the absolute lines of a surface on which it falls, it must have no definite outline—its edge must be slightly softened off. Observation will show the student that the extremes of a shadow are always more or less toned down into the tint of the surface on which it falls.

The right-hand side of the triangular base is next to be shaded, and then the shades on the feet. The cast-shadow on the ground, and that cast by the projecting edge of the top on the framing beneath it, will complete the drawing.

* "Unger's Ideal Views of the Primitive World, in its Geological and Palæontological Phases." Photographic illustrations. 4to. Edited by Samuel Highley, F.G.S., etc.

Fig. 621.

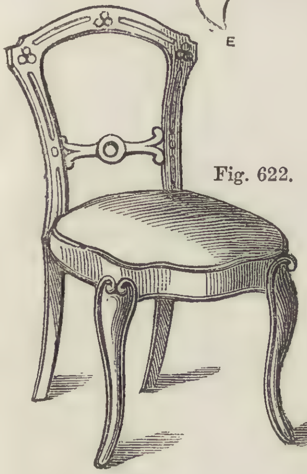


Fig. 622.

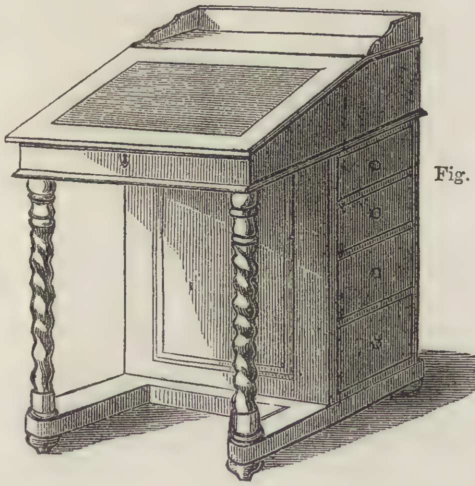


Fig. 623.

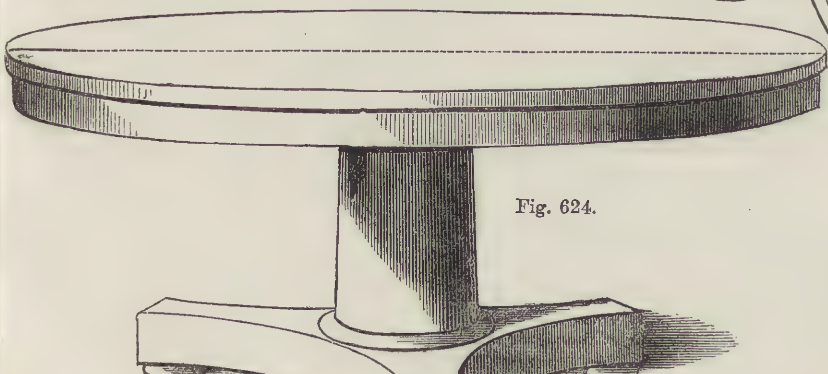


Fig. 624.

[NOTE.—A description of the mode, etc., of drawing Fig. 621 will be found in "Technical Drawing," LXXX., page 101.]

SEATS OF INDUSTRY.—XXXIII.

MARSEILLES.

BY WILLIAM WATT WEBSTER.

ONE of the oldest commercial towns in Europe, Marseilles, or properly Marseille, is the chief mart, and, in respect of population, the third largest city in France. About six centuries before the Christian era, a colony of Greeks from Phocæa, in the Ionian Confederation, obtained a grant of the site from Naunus, the king of a Ligurian tribe, and built a town there which they called *Massalia*, a name that was afterwards changed into *Massilia* by the Romans. For a long period the Greek settlers were assailed by the natives of the place, but they successfully defended themselves, and gradually extended their territory, planting several colonies along the adjacent coast, at Antipolis, Nicæa, Emporiæ, and elsewhere. The Massaliotes devoted themselves chiefly to commerce, and the republic they founded was from an early period celebrated for the wisdom of its laws and institutions. Under the domination of the Romans, Massilia continued for a long time to rival Alexandria and Constantinople in the extent of its trade. On the outbreak of the Punic war in 218 B.C., it was of sufficient importance to be received into the alliance of Rome, and the Massaliotes were useful and faithful allies of Cæsar during all his Gallic campaigns. In the great contest for supremacy between Pompey and Cæsar, the town espoused the cause of the former, and was besieged and captured, after a protracted and stubborn resistance, by the latter, who carried off all the ships, military equipments, and public money, and deprived the Massaliotes of their peculiar privileges. After this event the commerce of Massilia declined, but subsequently the town acquired a new importance as the school where the neighbouring Gauls learned philosophy and rhetoric. Cicero speaks of it as the Athens of Gaul. In the reigns of Augustus and Tiberius it was the principal seat of learning in the West, and many Roman youths received their education there, among whom may be mentioned Agricola, the conqueror of Britain. Between the time of Cæsar and the downfall of the Roman empire no remarkable event occurred in the history of Massilia, but its inhabitants acquired a high character for virtue, temperance, and simplicity of life.

On the downfall of the Roman power, Marseilles fell alternately into possession of the Visigoths, Ostrogoths, and Franks; and in the early part of the eighth century the larger and older part of the city was sacked by the Saracens, who destroyed the remains of the ancient monuments that previous barbarians had spared. The upper portion of the city, however, successfully resisted assault, and held out till Charles Martel and his brother Childebrand brought a strong force to its relief, and expelled the Saracens. During the latter half of the eighth century, and especially during the reign of Louis le Debonnaire, in the beginning of the ninth, Marseilles suffered severely from pirates. The republican government of the city, which was aristocratic in its character, and consisted of six hundred dignitaries called Timachi, from whom an administrative committee of fifteen were chosen, three of whom were in turn entrusted with the executive power, was maintained up till the tenth century, when Marseilles was brought under the dominion of the Counts of Provence. William I., Viscount of Marseilles, and his successors, retained sovereign power over the city till the twelfth century, and the change to a monarchical form of government would seem to have produced no bad effects on its industry, commerce, and arts. For some time after the restoration of republican institutions, Marseilles formed one of a confederation of similar smaller states, in which were included Arles and Grasse; but after a struggle which lasted for six years, the city was again compelled in 1243 to acknowledge the authority of the Counts of Provence. In a short time, however, Marseilles was involved in an unsuccessful war with Charles of Anjou, brother of Louis IX., who annexed it to his territory, and it remained in the possession of the house of Anjou till 1482, when Charles de Maine, the heir to the line of Anjou, bequeathed it to Louis XI., with a stipulation that the time-honoured liberties of the city should be respected. In 1524, Charles de Bourbon besieged the city with a large imperialist force, but the citizens, after a desperate struggle, succeeded in repelling their adversaries. Louis XIII. made Marseilles a station for the French navy, and provided it with a dock and arsenal; and one good effect that followed these measures was the dispersion of the pirates that had for many centuries infested the Mediterranean. A formidable insurrection broke out in the city, under the leadership of Noiselles, during the reign of Louis XIV., but the Grande Monarque personally suppressed the disaffection in 1660, and punished the Marseillaise by depriving them of their peculiar privileges. He at the same time built the citadel of St. Nicolas. Marseilles was frequently visited by the plague, and in the years 1720 and 1721 it suffered an attack of this fell disease which carried off between 50,000 and 60,000 of the inhabitants. Marseilles early and zealously espoused the cause of the first French revolution, and the celebrated patriotic and revolutionary hymn, composed by Rouget de Lisle, derives its name of the Marseillaise from the fact that it was first publicly sung by the Marseilles confederates in 1792. The revolutionary commotion, however, having nearly ruined the commerce of the city, its inhabitants in 1793 went over to the side of the Girondists. After the restoration the trade and industry of Marseilles revived.

The most famous of the old merchants of Marseilles was Jacques Cœur, who flourished in the first half of the fifteenth century. Jacques Cœur was born at Bourges in 1400, and was the son of a goldsmith and fur-dealer of that city, whose business he inherited and greatly extended. Throughout his whole career Bourges was the centre of the commercial connections that this merchant had formed with every district in France; but about the year 1429 he established a place of business in Marseilles, the ancient port affording excellent facilities for carrying on trade with foreign countries. For some twenty years he annually dispatched ten or twelve vessels to the ports lining the Mediterranean, to exchange the wares of France for the spices, silks, and other costly articles of the East. He was the original founder of the French trade with Egypt, and his dealings with that land were very extensive, the goods he obtained from thence being sold not only in his own but also in other countries. It was reported that he had at one period no fewer than three hundred agents in various parts of the world. Charles VII. gave him a grant of the mining districts surrounding Lyons, and so successful were his operations, that the common people believed that he was an astrologer, and had discovered the philosopher's stone. By commerce and mining this enterprising merchant amassed so much wealth, that "As rich as Jacques Cœur" became the French equivalent of the Latin proverb, "As rich as Crœsus." His sovereign appointed him Master of the Mint, first at Bourges, and afterwards at Paris, and he was subsequently made *Argentier*, or Treasurer to the Crown.

From the time of Jacques Cœur to the present day Marseilles has been the principal commercial emporium in the south of Europe. Some idea of the extent of its trade in the middle of the eighteenth century may be formed from the fact that in 1753 1,264 vessels entered its port, which was a large number for that date. A century later, however, its shipping had nearly increased fourfold in number, and considerably more in tonnage. In 1858, 4,787 ships, with an aggregate burden of 1,102,123 tons, entered, and 4,687 ships, with a collective burden of 1,030,077 tons, cleared the port. From the report of the British Consul at Marseilles, which has just been issued, we extract the following interesting statistics and notes relating to the commerce of the city in the years 1868, 1869, and 1870. Notwithstanding the disturbed state of France during the latter half of 1870, a larger amount of shipping visited the port in that year than in any preceding one. The aggregate burden of the sailing-vessels and steam-ships that arrived at Marseilles in 1868 was 2,171,463 tons; in 1869, 2,228,130 tons; and in 1870, 2,237,732 tons. For the same three years the sailing-vessels and steam-ships that left the port represented a total of 2,181,582 tons for 1868, 2,183,539 for 1869, and 2,190,854 for 1870. To show the rapid increase of steam-ships within the last ten years, it may be stated that the steamers entered and cleared at the port of Marseilles in 1861 represented an aggregate burden of 1,362,392 tons, while in 1870 they reached a total of 2,417,817 tons, or considerably more than one-half of the whole tonnage inwards and outwards during that year. In the latter year 364 British vessels, with an aggregate burden of 195,935 tons, and manned by 11,709 sailors, arrived at the port, and 352, with an aggregate burden

of 188,717 tons, and an aggregate crew of 11,480, left the port. In the foregoing numbers were included 148 British steamships, with a total burden of 122,519 tons, and a total crew of 9,263 men. Of these vessels 51 are the property of the Peninsular and Oriental Company, who at the end of the year quitted the Marseilles station, and adopted that of Brindisi for the Indian mail service. A very large passenger traffic has been carried on at this port for the past few years, the arrivals and departures fluctuating from 150,000 to 180,000 yearly. Marseilles now possesses 572 sailing vessels, collectively of 87,201 tons burden, and 119 steamers, of 94,872 tons. The custom-house revenue of the port for 1870 amounted to 18,009,370 fr., against 15,225,727 fr. for the preceding year. In 1864, which was an exceptionally brisk year, the total exports of Marseilles reached a value of 1,102,243,663 fr. The merchandise exported in the year 1867 was estimated to be worth 627,021,967 fr., and the precious metals 129,005,663 fr., giving a total value of 756,027,630 fr. Among the principal articles of export in that year were included woollen fabrics to the value of 37,000,000 fr.; silk goods, 32,000,000 fr.; cotton goods, 28,000,000 fr.; refined sugars, 35,000,000 fr.; and wines and spirits, 25,000,000 fr. A striking fluctuation in the importation of wheat into Marseilles for the past few years is noticeable in the returns. In 1870, 5,256,030 hectolitres (three hectolitres being equivalent to 1 quarter 0·254 bushels) came into the port; while in 1868 the quantity was 10,486,800, out of 15,918,500 hectolitres, which was the total importation of wheat into France in the same year. Of other grains, such as rye, barley, oats, and maize, 2,573,300 hectolitres were brought into the port in 1870. About 1,492,800 hectolitres of wheat and wheat flour were exported from Marseilles in the same year, 392,400 being sent direct to England. The raw sugar imported from abroad in 1869 amounted to 68,645 tons, and in 1870 to 76,390 tons; and in the former of these years 7,505 tons, and in the latter 1,911 tons of home-grown beet-root sugar were received in the city. In 1870, 44,214 tons of refined sugar were exported from Marseilles, of which 12,760 were sent to Turkey, 9,422 to Italy, 6,840 to Algeria, 2,358 to Egypt, and 2,888 to Greece; while about 4,000 tons of raw sugar were re-exported. Oil-seeds have recently acquired an important position in the commerce of Marseilles, the imports of this article for 1870 having amounted to 184,000 tons. These oil-seeds consisted of sesamum seed from the Levant, India, and the coast of Africa; linseed and cotton-seed from the Black Sea and Egypt; and cocoa and palm nuts from the coast of Africa. The oil-mills of the city turned out about 115,000 tons of oil-cake in 1870, 29,000 tons of which were shipped for England, out of a total exportation of 31,700 tons. There was a marked decline in the quantity of cotton imported into Marseilles in 1870 as compared with the three preceding years. In 1869, 150,572 bales came to the port, and in 1870, 98,884, about 19,000 only being brought from India. The annual value of the silk imported represents upwards of 100,000,000 fr., and the quantity landed at Marseilles in 1870 amounted to 32,039 bales, but a large portion of this and of the stock of silk at Lyons was re-shipped for England on the outbreak of the war. China, Japan, Bengal, Persia, Asia Minor, and the coast of Syria supply most of the silk brought to Marseilles. The wool trade of the city has fluctuated nearly to the same extent as the cotton trade, only 91,518 bales of wool having been imported in 1870 (the whole being brought from Mediterranean ports, with the exception of 4,654 bales from Buenos Ayres), against 139,910 bales in 1868. In 1870, there were imported into Marseilles 10,356 bales of sheep and lamb skins, nearly the whole of which came from the River Plate; 31,355 bales of goat-skins, mostly from Morocco; and 716,797 hides, of which 200,000 came from the River Plate, 60,000 from Brazil, and the remainder from other countries. The olive oil imported in the same year amounted to about 40,000 tons of ordinary quality for manufacturing purposes, and 5,000 tons of refined oil; and the oil-mills of the city produced 70,000 tons of oil from the various sorts of oil-seeds, 12,000 tons of which were exported. Owing to the direct importation of petroleum from the United States into the various Mediterranean ports which formerly drew their supplies from Marseilles, the trade in this article has recently declined, but 42,743 barrels of crude, and 32,797 of refined petroleum were landed in 1870. The exportation of wine from this port has considerably increased within recent years, 35,580 pipes having been shipped in 1869, and 26,963 in 1870; but the trade in spirits has fallen off, only 2,500 pipes having been shipped in 1869 and 1870 respectively, against 5,775 in 1866. About 15,000 tons of argentiferous lead were brought to the city in 1870, and a large portion of it was desilverised there. The blast-furnaces of Marseilles turned out about 30,000 tons of iron in 1870, from ore imported from Algeria, Spain, and Italy. Out of 627,000 tons of coal brought to Marseilles in the same year, 81,000 tons came from Great Britain; about 200,000 tons were consumed in the city, and the remainder was either used by the steam-shipping, or sent to the different countries of the Mediterranean. Some 70,000 tons of soap are annually manufactured in the city. The flour-mills of the district number about 100, and comprise 600 pairs of stones. Large quantities of flour are annually produced, and the exportation of this article is important, having amounted to 65,000 tons in 1870. About £600,000 worth of work was executed in the engineering establishments of Marseilles in 1867, which then employed 4,000 men, but there has since been a considerable falling off. Large quantities of cattle are annually imported into Marseilles from Algiers and Sardinia. From the former country 19,109 bullocks and 318,621 sheep were landed in 1868; and from the latter 16,173 bullocks and 715 sheep. In 1870 the figures were:—From Algiers 1,880 bullocks and 218,694 sheep; and from Sardinia 4,932 bullocks and 69 sheep. About a fourth of the sheep and a third of the bullocks are consumed in Marseilles, and the rest are driven into the neighbouring departments. The trade between Marseilles and Algeria is very extensive, as may be judged from the fact that 766 vessels, with an aggregate burden of 290,259 tons, left the port in 1867 for that colony, while 573 ships, of collectively 274,812 tons burden, arrived from it. Ship-building has almost entirely left the city, and little more than repairs are now done there. The sea-fishing, which a few years back occupied a considerable number of ships, now only occupies about a dozen, and between 300 and 400 men.

The harbour of Marseilles is one of the finest and largest in the world, being capable of accommodating 2,000 vessels. It comprises (1) the Old Port, which is 1,000 yards long, and 300 yards wide; and the Port of La Joliette, constructed in 1853, which is about 600 yards long and 460 yards wide, and is surrounded by spacious quays furnished with iron tramways; (2) the basins of Lazaret, Aren, and Napoleon, opened within recent years; (3) a very old and insufficient graving dock; and (4) two refitting docks constructed in the same canal that unites the Old Port with the Port of La Joliette. The latter port is formed by a breakwater 1,224 yards long, thrown out into the sea, running parallel with the shore, and at a distance of 1,312 feet from it. Marseilles is still deficient in quay-space, and ships have frequently to discharge their cargoes lying to three deep. The great dock warehouses, built of stone and iron, can contain some 40,000 tons of merchandise. Le Vieux Port is formed by an inlet of the sea which runs eastward into the heart of the city, and the roads are defended by the fortified islands of If (crowned with a castle, once a state prison), Pomeque, and Ratonneau.

In Marseilles, the western quarter, which is crowded with narrow, irregular streets, is the older, the poorer, and the seat of the principal industries. Connecting the old and the new towns is a beautiful street or promenade called Le Cours, planted with a double row of trees, adorned with fine fountains, and bordered with many elegant mansions. Here the shops and houses rival in splendour the finest of those in Paris. The new parts of the city are admirably laid out. A new town that sprang up with remarkable rapidity on the site of a hill removed in course of making the port of La Joliette, and on the land recovered from the sea, is known as the maritime city, and is capable of containing 60,000 inhabitants.

The city is healthy. There are few remarkable buildings or antiquities in Marseilles. The New Cathedral, which is supposed to be built on the site of a temple of Diana, is a basilica in the Byzantine style, shaped like a Greek cross, and surmounted by very picturesque domes. Marseilles is the capital of the department of Bouches du Rhone, and possesses a court of first jurisdiction, a court and chamber of commerce, an exchange, a royal naval observatory, a mint, an academy of sciences, belles-lettres, and art; schools of medicine, music,

drawing, and hydrography; a public library containing 60,000 volumes; botanical gardens, a picture gallery, and various learned societies. The population in 1861 numbered 219,984, or including the whole commune and the military, 260,910; and at present it is upwards of 300,000. There are about 900 *bastides* or villas in the vicinity of Marseilles.

CAPITAL AND LABOUR.—VI.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

COMBINATIONS OF LABOUR.

The possessors of property may unite together in order to make their property more useful to themselves, and so turn, in the language of economists, their wealth into capital. They may entrust the management of this capital to the hands of others, and they may, if they prefer it, manage their capital themselves. In the former case they will get interest, in the latter they will get profit as well as interest, or, as I have already explained the facts, they will get wages for the labour which they give in superintending their own property, together with a greater or less addition, according to the character of the business in which they are engaged, which will cover the risk of loss.

Now the labourer, when his economical position has been analysed, will be found, as has been generally stated before, to stand in exactly the same place that the capitalist does. His education and maintenance are, to all intents and purposes, an investment of capital for productive purposes. The duration of his powers is a matter of risk. He is engaged in an industry which will assuredly sooner or later wear him out, and therefore he does in his wages receive something which, over and above the risk which he incurs, will compensate for the inevitable exhaustion of the powers which make him an industrial agent. But as the remuneration of his labour, in the shape of wages, and of his employer in the form of profit, are really identical forms of economical distribution, there is a question which is constantly raised as to the relations between the employer and the labourer, and which is characteristic of them. I refer to the question as to whether the master gets too much and the workman too little, in the distribution of that which remains over and above in the market price of the article, after all necessary charges are liquidated.

A combination of labourers has for its object the appropriation to the labourer of a greater share in the surplus from which both wages and profit are derived. This object is not always assured, but it certainly subsists in all such combinations. It was historically the cause of these associations, for up to within fifty years ago the law inflicted serious penalties on all those who entered into combinations for the purpose of raising wages, and the law had adopted this policy for nearly five centuries. It was by no means surprising, when this law was repealed, that workmen entered into these mutual arrangements; for it is very natural that persons should think, as soon as they are permitted to do what they have been forbidden before, that there is some advantage to be gained by availing themselves of the permission.

But, apart from these historical circumstances, there are considerations, partly of principle and partly of fact, which justify the associations of working men for the purpose of bettering their condition, and obtaining an increase in their wages. It may be the case, as some persons of great judgment and experience have averred, that these arrangements can be proved to be superfluous, for that the rise in the wages of some kinds of labour may be explained by causes which are quite independent of trade combinations, that the power possessed by those who live by their labour of entering into such associations greatly varies, and that if the policy of these arrangements is expedient it ought to be available for all who might see good to take advantage of it. It may be proved too, perhaps, that the establishment of the system may in certain kinds of industry do great injury to the public at large, and in particular to that portion of the public which is least provided with the necessaries or conveniences of life. But even if these reasonings can be maintained, they will not militate against the justice of a combination of labourers, though they may disprove its expediency.

A labourer has something to sell. This is his labour. It is just as saleable an article as a pound of sugar or a yard of cloth, and its advantageous sale is as much a matter of interest to the labourer as the sale of sugar and cloth is to the grocer and the draper. Now, if it be admitted that capitalists can unite their capitals together in order to get advantage by mutual association, there can be in the nature of things no reason why labourers should not have and use the same liberty. A trade union is virtually a labour partnership. It may not be, and perhaps is not, the best form of labour partnership—we shall have occasion to recognise, hereafter, much more advantageous forms of association—but it is based on precisely the same principle as that which induces men to put their property together in order to found a bank, to construct a railway, or advance a loan to a government.

Part of the machinery by which a trade combination tries to enforce its regulations is a strike—that is, a refusal to work unless certain demands are conceded. Now such a course of action is very inconvenient, and occasionally very alarming. It may be very disadvantageous to the public, and still more disadvantageous to the persons who adopt the expedient. It may entail great loss, and may fail of its end. It may attain its end, and the public may suffer, because they may have to pay more for a service than the service has hitherto been worth. It may be superfluous, because the rise in wages which it is intended to achieve may come from natural causes. It may be even unfair, because it is possible that such a rise ought to come from natural causes only. But, judged by the ordinary practice of those who are engaged in business, it exactly corresponds with the line of action adopted by traders in goods. No one finds fault with a merchant because he speculates on a rise in the price of the articles in which he deals, and withholds his goods from the market in order that he may get a better price hereafter than the market offers him at present. Such speculations are justified on grounds of private right, and sometimes even on those of the public good. But a working man who, in concert with others, declines to work for wages which he thinks insufficient, is only doing that which is an admitted right in the conduct of business by a private merchant. No one would probably dispute his right to choose his own terms if he acted as an individual, and there is no reason in the nature of things why he should not act with others in seeking to obtain for all what he thinks will be for the good of all. On grounds of principle, then, combinations of working men have a clear economical defence.

They have a further justification in fact. There can be no doubt that in matters of bargain an individual workman is, as compared with an employer, in a weak position. The man who employs many hands has greater advantage in constraining a workman to accept terms, than an individual workman has of exacting them. There is not much doubt, whether they do so or not, that employers have naturally greater opportunities for uniting together, in order to adopt a common policy, than their workpeople have. Even if the men can be brought to act together, the power of endurance, however disastrous may be a trade difference, is greater on the part of employers than it is on the part of the men. The very fact that the employer is possessed of wealth which is generally saleable, while the workman is possessed of one kind of wealth only, which under the present circumstances he declines to sell, is positive proof of the superiority of position enjoyed by the employers.

In giving these economical excuses for those combinations and their action, I must not be supposed to think that such expedients are desirable, or under certain circumstances necessary. I only say that they are, under existing circumstances, defensible. They arise from causes which are in themselves exceptional. I may illustrate what I mean by a fact of my own experience. Before the outbreak of the American civil war, there were very few trade-unions in the United States. Just after the commencement of that war, a tariff was passed by the American Congress, of a highly protective character, in the interest of employers or manufacturers. I took occasion, in conversation with an American of eminence, to predict that speedily, under that tariff, the States would swarm with trades-unions. Events proved that I was right. But my prediction was based on the principle which I have often insisted on, that where there are employers and working hands there is always a question afoot, whether the profits of the employer do not take over-much from the wages of the workman.

ENGLISH CARRIAGE-BUILDING.—I.

BY A LONDON COACH-BUILDER.

INTRODUCTION—HISTORY OF CARRIAGE-BUILDING—ESSENTIALS—LUMBER AND PANEL STUFF—WORKING DRAUGHT—CANT-BOARD—STANDING PILLAR.

It is a moot point whether carriage-building is to be regarded as one of the fine arts, or whether it is to be classed among the branches of industry which are included in the list of mechanical trades. The question is well worth the consideration of all those who adopt carriage-building as their vocation in life, because on the conclusion at which they arrive depends, to a great extent, their chances of success; for the higher the opinion men entertain of their occupation, the more are they likely to pursue it as a labour of love. On the one hand, it is said that, although essentially and of necessity for its practical purposes a mechanical occupation, it nevertheless includes so much of what is termed *art* in the higher sense of the word, that it may justly claim to be considered more than a mere industrial manufacture. On the other hand, it is contended that this branch of industry is of so multiform and composite a character, that it cannot in any sense lay claim to individuality which is the characteristic distinction of an art.

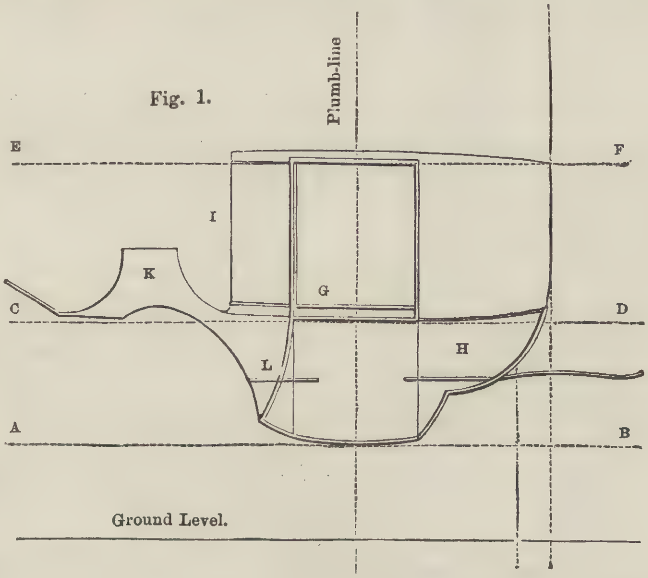


Fig. 1.

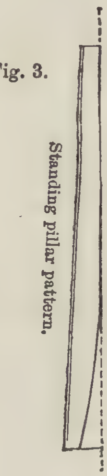


Fig. 3.

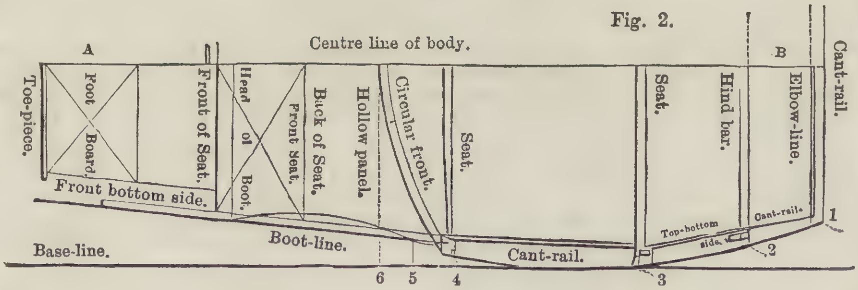


Fig. 2.

It is quite true that the occupation of the coach-builder differs widely in this respect from that of the sculptor, the painter, or the architect, or even from the pursuits of the goldsmith or the potter, inasmuch as each of these has to deal only with one substance, or one class of substances, and is dependent alone on his own efforts and skill; while the former has to deal with a great variety of materials of very opposite natures, and to command a whole train of auxiliaries, every one of whom must be well skilled in his department, or the work when completed will be marred, notwithstanding the superior abilities of the superintending head; but it is equally certain that if this same superintending head possess not in a high degree the distinguishing characteristics of the sculptor, the artist, and the architect, he will inevitably fail to make a proper use of the mechanical skill that is placed under his control, or to obtain a high position.

In the earlier ages of carriage-building, and even to a comparatively recent period, little was necessary to those engaged in it, beyond some rude knowledge of the laws of mechanics. No doubt the war-chariots of the ancient Greeks, described in the classic language of Homer, were very primitive constructions; the state carriage of our own Elizabeth, judging from the descriptions we have of it, must have been a very lumbering contrivance; and even the state-carriage in which "Mr. Speaker," only a few years ago, proceeded to St. Paul's Cathedral to take part in the thanksgiving service offered on the occasion of the recovery of the Prince of Wales from his severe illness, is little more than a venerable piece of gilt gingerbread. But the wonderful development of this elegant and useful branch of industry during the present century, especially during the last five-and-twenty years, has rendered far higher qualities essential for its successful prosecution, and under whatever heading it may be classified in the world's industries, the more eminent of our builders quietly pursue it as an art. That it is so considered in many European states is shown by the fact that in France, Belgium, and Germany, the respective governments have established technical schools, where youths intending to follow it are instructed in drawing, modelling, in the harmonious arrangement of colours, in chemistry, in metallurgy or the proper working of metals, and in the principles and applications of mechanics and mathematics to manufactures. It is to be regretted that more pains are not taken in this respect with our English apprentices, who mostly pursue their study of the different branches in which they are destined to labour with very little knowledge of the qualities or properties of the materials that are placed in their hands. But, notwithstanding our remissness, many of the heads of our large establishments have, by their own technical knowledge, and their taste and experience, overcome the difficulties that the want of a better system might be expected to give rise to, and if we pay a visit to their factories or show-rooms, we shall see at once to what perfection carriage-building has been brought in this country. We shall, moreover, be convinced not only that it is an art, but one calling forth no ordinary skill, for the carriage-builder has to combine in one harmonious whole a great variety of essentials, over each of which he must possess a mastery before he can succeed.

The art of carriage-building is of very high antiquity, and was still of ancient date in the days of Homer, who flourished about 900 years before the Christian era. The war-chariots of the Pharaohs are mentioned by Moses in the sacred writings, and it may be flattering to the pride of our English manufacturers to know that the scythe-armed chariots of the ancient Britons were copied and adapted by the Romans for purposes of luxury and convenience. But however much the Greeks or Romans may have elaborated their system of carriage-building, they made very little improvement upon the vehicles used by the ancient Egyptians, and after the fall of the Roman empire the art slumbered altogether for many centuries.

On its revival in the fifteenth century, it became rapidly a lucrative branch of industry, and attained great excellence, first

in Italy, and afterwards in Spain, France, and England. In 1668 Charles II. granted a charter incorporating the Worshipful Company of Coach and Coach-harness Makers in the City of London, conferring on them certain privileges and rights in order to encourage and protect a trade that had not been very long established in this country, and which was thought to require support. At that period trades were mysteries and their processes secret, and protection and support was required by that company in order to preserve those mysteries and processes inviolate.

For a long period none who embarked in this business was regarded in the trade as a legitimate carriage-builder, but he who had been brought up to the art of framing bodies or carriages. But in process of time it was shown that taste was the chief requisite, and as taste is not a necessary result of peculiar instruction, it followed that it must be had wherever it could be obtained; and others who had been brought up in different departments of the trade, such as painters, harness-makers, or smiths, were found to exercise the business with success. At the present day many men are engaged in it who have been brought up to professions or occupations entirely unconnected with carriage-building, and by their natural abilities, combined with excellent taste, they have often done more towards raising their adopted calling to the dignity of an art than some others who are able to boast of their practical experience and early training in the mysteries of the craft.

The protective theories of the "Worshipful Company" have long since exploded, but the company still exists, and, advancing with the times, its worthy representatives recently lent their hall for the purpose of an industrial exhibition of the operative coach-makers, the object of which was the very opposite of that for which the company was originally formed—namely, to court inquiry, comparison, and inspection of their work, with the enlightened desire to interest the public, by showing how much ingenuity, patience, and care are necessary for the production of a first-rate carriage. The mysteries and processes of the trade may therefore fairly be said to be thrown open, and without any violation of principle we are enabled to place before our readers some interesting details of the manner in which the elegant equipages of modern days are produced and turned out from our best establishments.

The first essential in a well-appointed carriage factory is a plentiful stock of well-seasoned timber, and of the different woods that are required in the process of carriage-building. There should be no timber used in a body or anywhere about a carriage that has not had at least one year in seasoning to every inch in thickness. After it has been cut into planks, it should be kept in a place where it will have a free current of air, each plank separated half an inch apart, with slips placed directly over each other, or the planks will be liable to warp.

Panel stuff should be treated in a similar manner, with the addition that it should be secured at the ends to prevent splitting; and when a body-maker commences his work, his first care should be to look after his panel, roof, bottom, side stuff, and lining boards, get them all planed up to their proper thickness, and put them up in some safe place where they will get a moderate degree of heat, each panel separated by slips; and all other stuff that will be required for the piece of work in hand, should be selected and put aside. If all these things be strictly attended to, there need be no trouble about bad joints; and it will be to the employer's interest to look after such workmen as do not know enough to see to these things themselves, and have these rules strictly enforced; but an intelligent workman will soon appreciate the advantage of getting his stuff ready at the commencement, instead of waiting till he wants to use it.

The timbers and woods commonly in use in our carriage factories are English ash plank, which is used for the framework of bodies and the timbers of carriages, Honduras mahogany for panelling, white pine for roofing, seat-boards, and the under parts of bodies, and birch for boot sides; but of late years Canadian black walnut wood has been advantageously introduced, and is often used in the place of birch, or being cut into panels is found, for many purposes, an excellent substitute for Honduras mahogany; the sapling oak or hickory is used for the spokes of wheels, and other woods are used for minor purposes. Many schemes have been tried for forcing the desiccation of timber, but we have no faith in any of them. The well-ventilated timber-shed, which gives alike protection against damp and the direct rays of the sun, offers the surest and safest means of seasoning or drying timber. Subjected here to atmospheric influence, the process may be slow; but while the moisture evaporates, the fibrous texture of the wood gradually consolidates, and none of its virtue is lost; while by any forced process the too rapid evaporation of moisture leaves the grain open and porous, and the virtue of the timber is more or less destroyed.

But before these timbers can be brought into use, it is necessary first to design the carriage that is to be built, and here we find at the outset that the eye and hand of the artist are wanted, for on the manner in which the carriage is first placed on the canvas entirely depends its appearance when finished: the importance, therefore, of a good draughtsman is at once apparent. In view of this vital necessity in the art of modern carriage-building, the Worshipful Company of Coachmakers annually offers prizes of silver and bronze medals for the best specimens of freehand drawing, as well as for practical mechanics; and, in addition, two silver and two bronze medals for drawings of carriages *to any scale*, for competition among foremen, workmen, or apprentices engaged in the trade. It is gratifying thus to see this ancient City guild striving to promote the best interests of the trade, for the special benefits of which it was originally established, while all others similarly called into existence have outlived everything connected with the industry they represent, except the name.

For the purpose of designing the working draught, a large size black canvas is usually placed against one side of the wall of the wood-loft; on this the draughtsman sets to work to delineate the body the full size. First with a plumb-line he strikes a vertical line down the centre from the top to the bottom of the canvas; by means of this line and a square board he is enabled to strike a horizontal line along the bottom of the canvas which forms his ground-level. We will suppose the carriage wanted to be a brougham, as represented in the first diagram (Fig. 1). He next proceeds to strike the three lines, A B, C D, E F, parallel with the ground-level. A B represents the intended height of the body from the ground; C D the depth of the door below the door-rail, G, and the hind quarter, H; and E F the extreme height of the body on the side. These three lines form the basis of his operations. By making his plumb-line mark his central line, he measures off, first the width of the door of the body, then the depth of the hind quarter from the door-pillar to the back of the body, then the depth of the circular front, I, from the front of the door to the centre of the circle. When he has obtained these measurements, and added thereto his seat-line back and front, he has nearly all the measurements it is necessary he should work to in delineating the outline of his body; the rest is mostly regulated by his eye. These measurements are, of course, made by the required inside capacities of the body; they, therefore, are not altogether arbitrary, but depend very much upon the manner in which it is intended to construct the body. It is requisite, therefore, that the draughtsman should have an intimate knowledge of the best mode of such construction. The width across the boot-side K, at the front inside seat-line L, will have to be regulated by the required depth of the seat from back to front, and the height of the arch by the intended height of the front wheel.

Having arranged all his lines and curves in pleasing and graceful form, and finished his drawing to his satisfaction, he next proceeds to prepare his cant-board, which, to the workman, is far more important even than the drawing itself. The drawing presents the side view of the body on the flat; but as it is not intended to build it flat-sided, but with a nicely rounded surface, it is essential that this rounding shall be planned out before the work is commenced.

The rounding which is given from end to end of the body is technically called the *side cant*, and the rounding from the top to the bottom the *turn under*. We have heard of carriage-builders, and of men eminent in their vocation at the present day, allowing this rounding process to be performed in their factories in a very primitive way. The timbers which are to form the frame-work or skeleton of the body are cut square and framed together, and then chiselled off to the required roundness, as a stonemason would chisel off blocks of granite, or as Robinson Crusoe gave form to his boat out of the solid tree. We can hardly credit this, for the waste both in time and material must be enormous, nor do we believe that modern requirements can be adequately fulfilled by such a process. The

proper plan is to arrange everything beforehand, and this is done on the cant-board which shows the side cant, and with the standing pillar pattern which shows the turn under. The manner of proceeding is as follows:—

Take a clean pine board, plane it up to a smooth surface, and run the outer edge with a trying plane, so as to render it perfectly straight. This straight edge of the board must now be taken to represent the flat surface of the side of the body, and along it must be marked off the dimensions of the body, beginning at the top corner pillar marked 1, and following the figures 2, 3, 4, 5, and 6. From 1 to 6 will thus give the extreme outside measurement of the body, and the respective measurements from point to point.

To illustrate the system, we must now draw attention to the diagram showing the cant-board, which is drawn to scale of half an inch to the foot. The first mark on the board shows the position of the corner pillar, the second the hind bottom-side, the third the hind standing pillar, the fourth the back of the front pillar, the fifth the toe of the front pillar, and the sixth the outside of the circular front of the body. The circular line between these points shows the contraction from the widest part of the body, and the manner of distributing it from end to end; and the line A B, which runs parallel with the base-line of the cant-board, shows the centre of body from side to side. The lines which follow the point which shows the outside of the circular front mark the boot-line, the arch beneath, the hollow panel at top, and all the distances from point to point till we come to the toe-piece, or extreme end of the body and boot as a whole. All these delineations give us the exact plan, together with the dimensions of the body in every particular, except the turn-under.

We only now require the standing pillar pattern to give us the contraction at the bottom; we can then proceed to give the dimensions in full detail from side to side of the body, the width across the widest point being first determined by arbitrary decision.

The standing pillar, as probably our non-professional readers will have already surmised, is that on which the door is hinged. We have described it on the cant-board, to scale which shows the turn-under to be $2\frac{1}{2}$ inches, so that the outside width of the body at the bottom will be five inches less than at the elbow. It may be as well here to state that there is no rule about the side-cant or the turn-under; they depend entirely upon the will or taste of the workman.

SEATS OF INDUSTRY.—XXXIV.

LE HAVRE.

BY WILLIAM WATT WEBSTER.

"PARIS, Rouen, and Le Havre form but a single city, of which the river Seine is the principal thoroughfare." So said Napoleon Bonaparte, President of the French Republic, to a deputation from Le Havre who, having learned that he was on his way to their town, met him at Rouen, and assured him of an enthusiastic welcome. This was in the year 1802. The professed object of Napoleon's visit was to contrive means by which the commercial facilities of "the Port of Paris," as he designated Le Havre, might be improved, and he prophesied that a great future was before it. It was destined, he declared, to rival the most renowned ports of Europe, and to direct, for the profit of France, a portion of the trade by which the Hanseatic towns and the Dutch ports had successively enriched themselves. But Napoleon did nothing to fulfil these predictions. Eight years later he returned to Le Havre, and although in 1805 the town had profited by the large share it took in providing boats for the fleet that the ex-first consul, and by that time Emperor of the French, fitted out at Boulogne for the conquest of England, he found its commerce and industry had considerably declined in the interval. During nearly the whole of that period, the port had been closely blockaded by an English squadron. English men-of-war were then in possession of the roads, and their presence, and the desolation of the town, reviving the memory of recent defeats in Spain, at St. Jean d'Acre, Trafalgar, etc., drove the Emperor into a towering passion. There was no talk now of the commercial interests of Le Havre, and it was only after the downfall of Napoleon that the town recovered its trade and prosperity.

At the date of Napoleon's last visit, Le Havre was about 300 years old, having been originally founded in 1509 by Louis XII., who intended it as a harbour of refuge for the French navy; but little progress was made in its erection during that monarch's reign. The word Havre signifies "port," and is supposed to be a corruption of the Celtic *aver*. Francis I. took the town under his protection, and conferred on it the name of *Franciscopolis*, but under Louis XIV. it was designated *Le Havre de Notre Dame de Grâce*, and, with the exception of a short period during the Reign of Terror, when it was re-christened *Le Havre-Marat*, it has been known by that title and its abbreviations, *Le Havre de Grâce* and *Le Havre*, ever since. Before the time of Louis XII., Le Havre was a small fishing village on the border of a marsh, and the port was a creek formed by the tides. It was from this place that Henry of Richmond embarked in 1485, with 4,000 men furnished by Charles VIII. of France, for Milford Haven and Bosworth Field. In 1516 the decree for the erection of a fortified town and harbour at Le Havre was issued, and in the following year the first stone houses were built. The first large vessels entered the port in 1520; but five years later the works were wholly destroyed by a high tide. Francis I. entertained the idea of building a fleet, and setting out from Havre for the conquest of England, as William of Normandy had started from Honfleur on his successful expedition five centuries before. But the project ended in a series of ridiculous catastrophes. An enormous vessel of upwards of 2,000 tons was constructed, and heavily plated; but it was found that she could not be launched, and her timbers were eventually used in the erection of houses for the burghers. Still Le Havre continued to grow, and Francis made it the rendezvous of his navy. At this king's death, in 1547, the town possessed formidable defences against its two enemies, the sea and the English, and was on a fair way to prosperity.

Le Havre has suffered severely from war almost from the time of its foundation down to the year 1871. In 1562 the Prince of Condé, the leader of the Huguenots, delivered the town over to the keeping of Queen Elizabeth, who entrusted the command of it to Ambrose Dudley, Earl of Warwick; but within a year the English were expelled, after an obstinate siege, directed in person by Charles IX. and his mother, Catherine de Medici. A citadel having been built, and Le Havre being regarded as a place of strength, it was frequently assailed. It has been four times bombarded by the British, in 1694, in 1759, in 1794, and in 1795. On the first of these occasions, preparations were being made at the port for another invasion of England. During the minority of Louis le Grand, the commerce of Le Havre, being skilfully fostered by Richelieu, made a rapid advance; and about this time the Queen of Charles I., accompanied by her daughter, the Princess Henrietta of England, took up her abode within the walls of this town. The names of Vauban and Colbert are associated with the improvements made in the port in the reign of Louis XIV., and with the development of the trade of the town.

In 1716, the second year of the reign of Louis XV., the North Jetty, which had long been in progress and frequently interrupted, was completed, and in the same year a curious phenomenon is reported to have taken place at the port. The tide rose to a greater height than had been previously known, and remained at that elevation for twenty-four hours, doing a great amount of damage. The French East India Company and the companies of Senegal and Guinea made Le Havre their entrepôt, and the chief seat of their commercial operations. With the exception of visits from the Kings of France, and the sieges by the English, which have been already referred to, no other events of great interest or importance took place at Le Havre till the time of Napoleon, and the incidents since that date are not of a remarkable character.

In the beginning of 1871 the town was threatened with an attack by the Germans, and the inhabitants were consequently filled with anxiety; the docks were empty, the warehouses nearly bare of goods; industry was at a standstill, and the hospitals were filled with wounded soldiers. But the armistice came in time to save the town from the horrors of a siege, and on the conclusion of peace its merchants set promptly and actively to work to replenish their exhausted stores. However, although during three months of the year commerce and industry were in a state of stagnation, the operations carried

on throughout the remaining nine months were so extensive that 1871 was, on the whole, a prosperous year for the city. In 1871, 1,379 British vessels, aggregating 510,602 tons burden, and with crews numbering in all 23,776 men, entered the port, against 1,371 British vessels, aggregating 520,019 tons burden, and with crews numbering in all 26,397 men, in 1870. During both of these years the number and burden of the British shipping that visited the port were greater than in the three preceding years. The total entries of shipping of all nations at the port of Le Havre in 1871 amounted to 6,274 vessels, representing an aggregate burden of 1,340,915 tons, and an aggregate crew of 70,842 men, 2,572 of these vessels being engaged in the foreign, and 3,702 in the coasting trade. In 1869 the total entries of shipping numbered 5,713, with an aggregate burden of 1,323,286 tons, and an aggregate crew of 71,162 men.

Besides an immense outer harbour, with 1,600 mètres of quay, there are eight tidal basins, including one opened last year, and two lock basins, at Le Havre. The Old Basin, excavated in the time of Richelieu, has been repaired and rendered accessible to the largest vessels. The Commercial Basin can accommodate with ease 200 ships, and the Basin de la Barre is still larger than the Commercial Basin, with which it communicates. The new dock is a fine piece of work, and preparations are being made for widening the entrance to the port, and removing an angle where many large steamers have run aground. There is a peculiarity of the harbour of Le Havre that deserves to be mentioned. It has the great advantage of retaining the tide at nearly full height for three or four hours, whereas elsewhere the tide begins to recede from the time it ceases to rise. This phenomenon, which has never been satisfactorily explained, permits ships to enter and leave the port by the same tide. The coasting vessels arriving at Le Havre transfer their cargoes to steamers, and partly to large barges termed *chalands*, which are towed by steam-tugs as far as Rouen, and thence by horses to Paris. Lines of sailing packets are established between this port and New York, New Orleans, etc., and there is regular steam communication between it and London, Southampton, Liverpool, Dublin, Glasgow, Hamburg, Rotterdam, St. Petersburg, Constantinople, Odessa, Havannah, St. Domingo, Vera Cruz, and the principal maritime towns of South America, India, and China.

Most of the foreign and colonial produce destined for the consumption of Paris is imported into Le Havre; and although its imports are only about half the weight of those of Marseilles, there is little difference in the total value of the imports of the two towns. The principal imports consist of cotton, coal, sugar, coffee, indigo, timber, iron, tin, dried fish, hides, and tobacco; and the principal exports are silks, woollen and cotton goods, lace, gloves, shoes, trinkets, perfumery, champagne and other wines, brandy, glass, furniture, and books. Le Havre is to the north of France what Marseilles is to the south, and it ranks next to that city in the extent of its shipping trade, the commerce of Le Havre being estimated at between a fourth and a fifth of the whole of France. In 1867, 22,752 emigrants sailed from Le Havre, and in 1864 there belonged to the port 368 merchant ships, with a total burden of 114,645 tons. There are three extensive ship-building yards in the town, and numerous establishments for the manufacture of all the articles required for the outfit of vessels. The rope-works are highly celebrated, and the sugar refineries, one of which furnishes employment to 250 workmen, are very large. One firm of sugar refiners at Le Havre are reported to have distributed among their workmen, out of their profits last year, no less a sum than £10,000.

In the spinning factories of the town 14,500 spindles are kept at work, and 550 workmen find employment in 370 weaving shops, while 580 are occupied at the tobacco factory. The engineering establishments and copper foundries of Le Havre are very extensive, and it also possesses large corn and rice mills, and glass and chemical works. It is estimated that the total annual value of the manufactures of Le Havre exceeds £2,500,000. The total value of its exports and imports amounts yearly to about £52,000,000.

In 1861 the population of Le Havre numbered 82,009, exclusive of from 5,000 to 6,000 men and boys, forming the crews of the vessels constantly in the port. Lately the walls of the town were demolished to allow of its expansion. Le Havre contains few public buildings of note either for their elegance or for their age and associations. With the exception of a few wretched wooden houses, the town is substantially built, and the streets are laid out with great regularity in straight lines, which intersect each other at right angles. A few magnificent streets and boulevards have recently been constructed, and great progress has been made in the embellishment of the town. Le Havre is the birth-place of Bernardin St. Pierre, the author of "Paul and Virginia," and Casimir Delavigne, the author of the celebrated play, "Louis XI."

WOOL: ITS INDUSTRIAL APPLICATIONS.

BY PROFESSOR T. C. ARCHER.

II.—THE ANCIENT USES OF WOOL AND OTHER ANIMAL FIBRES.

Before wool can be applied to any economic purpose it must be removed from the skin of the animal, and this in our time is done by shearing with sharp steel shears; but wool was used long before such implements were invented, and was probably obtained first by collecting the stray locks, which were detached by thorns, and other causes, from the animal whilst alive. Doubtless, also, it was pulled from the skins of animals slaughtered for food. In most climates the sheep parts with the outer layer or oldest portion of its mature wool in the spring of the year by a natural process of moulting, and this would afford the rudest barbarian a very easy means of collecting it, but not perfectly or in good order, and a knowledge of this imperfection in time would lead to the invention of shears, and a great improvement in the wool crop, for not only would the first yield be larger and better, but the equally shorn and short covering left would grow more regularly, and ensure an improved clip for the next season. The most ancient practice of pulling the wool at the proper season from the skin of the living animals, notwithstanding its great cruelty, has continued in some localities even up to the present century, chiefly in Iceland, Shetland, and Orkney, but it is now almost, if not quite, abandoned.

When shears were actually invented is not known, but it is certain that this implement existed at least 1800 years B.C., because we read in the Book of Genesis that "Laban went to shear his sheep," and from that time to the present they have been generally used by the most civilised nations, whilst those less so have pursued the old and barbarous custom of pulling the wool. In each case it would have to be combed and spun into thread, by processes which will be described in a subsequent chapter, our present object being rather to make the reader acquainted with the ancient applications of the material.

It is impossible to give any opinion upon the time when the wool of animals was first used for garments. The Bible contains more information upon the subject than any other book, though much is found scattered through the writings of classic authors; but recent discoveries of the remains of pre-historic life seem to point to an antiquity for the manufacture of clothing from wool far greater than we have been accustomed to assign to it, and this is rendered all the stronger when we consider that ancient authors, both Biblical and classical, all speak of the art as one in which great perfection had been attained. Thus we read in Exodus xxxv. 35, Moses says, "And of the weaver, even of those that devise cunning work;" and many similar passages could be quoted.

But notwithstanding the very abundant evidence that the weaving of cloths of wool dates back to the commencement of historic times, some authors advance strong arguments in favour of the supposition that the art of producing woven cloth for apparel was not the first application of wool. There are many reasons for this assumption, foremost amongst which is the probability that the felting property of wool would be noticed by the wearers of sheep-skins, which we naturally suppose was the first method of utilising the material for the purposes of human clothing. From long-continued use portions of the wool on the skin garments would become felted, and this being observed would suggest the employment of loose wool, by working it up into felt for garments, but the earlier application of felt was in all probability confined to the manufacture of small

articles, probably entirely to the manufacture of hats. It would be very interesting if we could establish the truth of this suggestion, because it would show that this application of wool was coeval with man's civilisation, and has continued in use up to the present time. As a covering for the head, certainly felt is the earliest material known, and both the statuary and other artistic representations of the ancient Greeks and Romans afford abundant evidence of such hats being generally worn. Thus in most of the representations of the ancient inhabitants of Troy and Phrygia, and the inhabitants of Asia Minor, as well as some mythical personages, such as Ganymede, a felt cap of the fashion known under the name of the Phrygian bonnet (Fig. 14), or "Cap of Liberty" of the moderns, is the head-dress, whilst a felt hat of another, but equally common shape, is usually placed on the head of Mercury (Fig. 10): these, with various modifications shown in Figs. 7 to 16, seem to have been almost universally used in Europe and Asia for a very great period of time, and they are still represented by the Moorish fez and the English "Jim Crow," etc.


Fig. 9.


Fig. 8.


Fig. 15.


Fig. 10.


Fig. 11.


Fig. 16.


Fig. 7.


Fig. 12.


Fig. 13.


Fig. 14.

But the discovery of the art of making felt could not long be confined to hat-making, and in time it was employed instead of skins to make a cleaner and more wholesome dress for the whole body. The Greeks were well acquainted with the manufacture and use of felt as early as the ninth century B.C., for it is mentioned in the Homeric poems ("Iliad," x. 265), and by Hesiod ("Op. et Dies," 542, 546); but it is most probable that they received the art from Asia, where both in Northern India and Persia it has been practised from a very high antiquity. The Persians used it as a covering for their horses, and most likely also for carpets. The Romans in the time of Julius Cæsar wore felt shirts as a protection from the arrows of Pompey's archers, and it is pretty certain they had learned this fashion from the Greeks, who also wore a *chlamys* of felt occasionally.

Felt shoes and linings for helmets were also amongst the ancient applications of this material, and the former use has endured to the present time, especially amongst the Russian peasantry, and poor classes in the towns, who use hats, coats, boots, and shoes made entirely of felt, and each article in one piece. We have evidence that the ancients manufactured felt on a large scale, to screen the defenders of fortifications from the missiles of the enemy.

We now proceed to examine the history of woven woollen cloths, and other applications of the material in ancient times.

No record exists of the actual invention, or even the probable time of the invention of weaving, and the earliest mention of woven woollen cloths indicates an advanced state of the art. Moreover, it must be borne in mind that the evidence of all ancient history is against the assumption that the vast flocks which constituted the wealth of the peoples described in the sacred writings and by classical authors, were not as a rule reared for food, but for either their skins or their fleeces. Thus we read in Proverbs xxvii. 26, 27, "The lambs are for thy clothing, and the goats are the price of thy field; and thou shalt have goats' milk enough for thy food, for the food of thy household, and for the maintenance of thy maidens." In this quotation it is clearly indicated that the chief use of the sheep was to furnish either skins or fleeces for clothing, and that of goats to yield milk of which cheese was made. But there is no reason to doubt that from the earliest times goats' hair was used for various textile purposes, and the milk of sheep was also used for food. Columella says the Nomades and the Getæ were called Galactopotæ because they were drinkers of ewes' milk. It would be very satisfactory if we could discover in any of the tombs of the ancients such satisfactory specimens of their manufacture of wool into clothing, as we find in the Egyptian tombs of linen cloths; but the liability of all animal substances to the attack of moths and other insect enemies, has probably prevented that, although specimens of fine cloths made of alpaca wool are said to have been found in some of the most ancient of the Peruvian places of sepulture.

Possibly the use of goats' hair for weaving is coeval with that of the wool of sheep; its greater length and silky fineness are more suggestive of such application; at all events, we learn from Exodus that it was spun and used in the form of cords and curtains for the tabernacle, and there are many allusions to the use of goats' hair cloths in the classic authors. Much coarse cloth at the present time is made in the East, chiefly in Syria, of goats' hair, and is used for tent-cloths, or for bags and sacks for agricultural produce, and the wrapping in bales of manufactured goods. This cloth is called in Syriac and the allied languages *shac* or *sac*, whence we obtain our word *sack*. And in view of this origin of the term we must always understand the term "sackcloth," so often alluded to in the Scriptures, to mean cloth of goats' hair. Besides cloths made of goats' hair, the material was much used by the ancients for cordage, especially for the rigging of ships. Aristotle, Callisthenes, Varro, Virgil, and Pliny all refer to this use of goats' hair, and tell us that the goats were then shorn the same as sheep.

Of the fabrics made from wool or hair, either of the sheep or goat, by the ancients, we find only meagre mention. Nevertheless, there is enough to show that such fabrics were manufactured, and became articles of luxury from the fineness and beauty of their manufacture, as well as of utility. Thus we find Strabo and other ancient authors speak with great respect of the Coraxi, who seem to have been the progenitors of the modern Circassians, as a nation who greatly excelled in the art of rearing flocks and utilising their fleeces. Moreover, Hipponax, who wrote 500 B.C., has left evidence that in his time that nation was celebrated for its manufacture of shawls, as he speaks of a woman wearing a Coraxic shawl. The same writer also speaks of the carpets of Miletus as being very famous. As, however, Miletus was the great port of Ionia, and at least a portion of Circassia was at that time occupied by an Ionian colony, we can easily understand the probability that Miletus was the mart for, and not the place of manufacture of, the beautiful carpets for which it was famous. The shawls possibly resembled, if they were not identical with, the Cashmere shawls of the present day, and the carpets were possibly felt cloths,

in which the patterns were felted in by a process which was shown in the Indian Department of the International Exhibition of 1871, and which possibly originated in the shawl manufacture. The examples alluded to were very curious; they were thick felt carpets, or *musnuds*, for sitting upon, and the patterns were in various colours on a drab ground; they were formed, not by any kind of printing process, such as would be employed in Europe for decorating felt fabrics, but by laying coloured wools, probably the refuse of the shawl manufacture, so as to form the patterns, and then beating them into felt. In this manner very effective and beautiful carpets were produced.

But besides the shawls and carpets of the Coraxi, the Ionians imported in all probability the wool itself, and rivalled them in the manufactures they produced from it, for Miletus is very frequently spoken of as the emporium for the finest of woollen manufactures, and those which were understood to be made at Miletus were regarded as the finest of all; so much so, that the term Milesian came to be employed as a distinctive appellation for wool of the finest quality. Whether the animals themselves were also imported is not known, but it is certain that not far inland from the port of Miletus there was a district in which wool of remarkable fineness was grown.

This part of our subject has been more indebted to the numismaticians than to any other for its elucidation, for it is chiefly on the coins of the ancients that we find all the varieties of costume of the periods when the coins were struck, and the information we are thus enabled to gather is often very interesting. Thus we learn that there is but little variation in fashion, from the most ancient Greeks to the most modern, in the form of the head covering, the *pileus* of the former, as represented in Figs. 11 and 16, being nearly the same as the modern fez, minus the silk tassel. When a brim was added to the *pileus* of the ancients, as in Figs. 8, 9, 10, 12, it was called a *petasus*, and was an indication of a superior position. The conical forms shown in Figs. 13 and 15 are Persian, and were called *tiara* by the Greeks, whence we derive our name for the Papal crown. In writing the present paper it has been necessary to have frequent recourse to the exhaustive work on this subject by the late Mr. James Yates, whose "Textrinum Antiquorum" embodies all that is known of the ancient uses of the material, and will ever be a work of the highest importance to those who seek for the soundest information as to the clothing of the ancients. In our next paper we shall show the progress in the application of wool since the commencement of Christianity.

SHIP-BUILDING.—XXI.

BY W. H. WHITE,

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THE RIVETING OF IRON SHIPS.

REPEATED references have been made to this subject in preceding articles, and the importance of good arrangements of riveting has been again and again enforced. Numerous examples have also been given of the methods of fastening together different parts of iron ships; but respecting many important facts and principles relating to rivet-work, nothing has yet been said; and as the matter is most important, we shall consider it in detail to some extent.

A great mass of facts respecting the strength of rivet-iron, of manufactured rivets, and of riveted work, has been got together as the result of experiments made primarily with a view to the improvement of bridge construction; and the knowledge so gained has also been of benefit to iron ship-building. Very few experiments were made in direct connection with ship-building until the new material came into general use in the Royal Navy; but since then numerous and valuable experiments have been made, from which have resulted considerable improvements. There still remains, however, much to be made the subject of trial in connection with the riveting of wrought-iron or steel structures, as any one will see who carefully goes through the excellent summary of our present knowledge on the subject, published by Mr. Reed in his "Ship-building in Iron and Steel."* For our present purpose it will suffice, however, to state clearly well-ascertained facts, and to draw a few practical deductions therefrom.

In Fig. 41 (Vol. III., page 351) an illustration is given of the form of rivet commonly used in iron ships, with what is termed a "pan-head." Sometimes the head is hemispherical in shape, and is termed a "snap-head;" but this is not extensively used. The process of making these rivets is a very simple one. First the bar-iron is heated in furnaces; then it is cut into the lengths required; and lastly, the head and the conical neck of each rivet are formed by being pressed into suitable dies. These operations were formerly performed by hand, but now they are done by machines—some of which are most ingeniously arranged—at much less cost and at a very rapid rate.

When required for use, the manufactured rivets are heated in portable hearths made for the purpose, means being commonly taken to keep the head and neck at a lower temperature than the shank. After becoming sufficiently hot, the rivet is driven through the holes in the plates or bars it is to fasten together, and a workman, termed the "holder-up," presses against the head with a heavy hammer, or a mass of iron termed a "dolly," while two other men, termed "riveters," beat down or clench the rivet-points with hand-hammers. When the point has been "knocked down," the riveters hold their hammers upon it while the holder-up gives the head a few blows, or "lays it up;" and when this has been done, a few more blows on the point finish the operation.

The foregoing is, in brief, the operation of *hand-riveting* which is adopted for by far the greater part of the work in iron ships. Riveting machines have, however, been in use for many years, and may be advantageously employed in fastening together such portions of the structure as can be completed, or nearly completed, before being put in place—viz., deck-beams, frames, etc. Portable riveting machines have also been devised, but have not yet found much favour, and do not seem likely to displace hand-riveting very soon. Experiments have been made to test the comparative merits of the work produced by riveting-machines and by hand-riveting, with the result of showing that the two methods are practically equal. The machines, doubtless, have the advantage as respects cost of work, when they are employed under favourable conditions, and are very largely used in bridge construction, where large pieces of the structure can be riveted-up before being put in place; but in ship-building, the outside plating, the deck-plating, stringers, ties, keelsons, etc. etc., can only be riveted-up in place, and under conditions which do away with much of the advantage otherwise obtainable from the use of machines.

There are three common forms of rivet-points—the *countersunk* (Fig. 40, Vol. III., page 351), used where a flush surface is required; the *snap* (A, Fig. 58), used for inside work, beams, bulk, heads, keelsons, etc., where it is unnecessary to make flush surfaces; and the *conical* (B, Fig. 58), sometimes used instead of the snap-point, but more commonly employed in boiler-making than in ship-building. The first and third points can be formed with hand-hammers only by the riveters; the second requires the use of a cup-shaped die, in order to give it the finished hemispherical form, this die being driven over the point after it has been roughly formed.

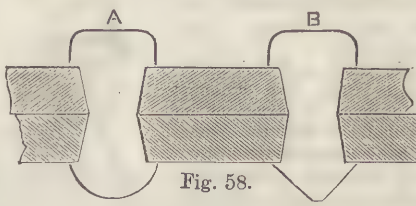


Fig. 58.

From the preceding remarks it will be obvious that the iron from which rivets are made needs to be of very superior quality, in order that it may successfully withstand the manipulation of manufacture and knocking down the point. Lowmoor, Bowling, and other Yorkshire irons are largely used for rivets, but not to the exclusion of other makes. Steel rivets have been also used, but they require very careful treatment, and are not to be depended on so thoroughly as iron rivets; for which reason it is generally considered preferable to use the latter, even in steel-plated ships.

Rivet-holes are almost always punched in plates and bars, the more expensive operation of drilling being had recourse to only in special cases. In a previous paper it was remarked that the

* Chap. XVII., on "Rivets and Rivet-work," gives most of the best experimental results hitherto published, including those obtained in the Royal dockyards. From it we draw most of the data used in our treatment of this question.

strength of a plate of iron was reduced somewhat by punching. Mr. Reed states that this reduction may be taken as about four tons per square inch of sectional area for iron, which would, when unpunched, stand a tensile strain of twenty-two tons per square inch, supposing the plate to be perforated by a row of holes such as would commonly be required for butt-fastenings. With steel the reduction in strength produced by punching is still more considerable, and it is considered advisable either to drill the holes or to anneal the plates after the holes are punched, in order to avoid this disadvantage. The gain in rapidity and cost of workmanship due to punching as compared with drilling, leads, however, to the continuance of the former method, which has, besides, the advantage of giving a slight countersink, or conical form, to the hole, as explained in page 351, Vol. III. We would also refer the reader to the remarks there made respecting the necessity for care in determining the side *from* which holes should be punched in plates.

Turning next to the relation existing between the thickness of plating and the diameters of rivets used, we will first of all give a tabular statement showing the practice of the private yards, as represented by Lloyd's rules, and that of the Royal dockyards, as stated by Mr. Reed. The thickness of plates and diameter of rivets are in sixteenths of an inch.

THICKNESSES OF PLATES.	DIA. OF RIVETS. Lloyd's	DIA. OF RIVETS. Gov. Serv.	THICKNESSES OF PLATES.	DIA. OF RIVETS. Lloyd's	DIA. OF RIVETS. Gov. Serv.
5	10	8	11	14	14
6	10	10	12	14	16
7	10	12	13	14	16
8	12	12	14	16	18
9	12	14	15	16	18
10	12	14	16	16	18

It will be observed that in no case is the diameter of the rivet less than the thickness of the plate; and it is found in practice very difficult to *punch* a hole of less diameter than the thickness, nor is it desirable to do so in most cases, although, when required, smaller holes can be drilled. In no case, also, is the rivet's diameter greater than twice the thickness of the plates—an upper limit which experiment and investigation agree in fixing. The table holds good for two thicknesses of plating, or a plate and a bar; if three thicknesses are to be fastened, the diameter of the rivet is usually made a little greater. The diameter of the rivet is also generally estimated from the thickest piece in a combination. The holes in the plates are punched a little larger (about one-sixteenth of an inch) than the diameter of the rivets, so that when heated and expanded they may be easily introduced into the holes. All these are practical details which experience has proved to be of considerable importance, and respecting which ship-builders do not differ materially.

Experience has also had most to do with the determination of the proper spacing or "pitch" of rivets in various descriptions of work. When joints are to be caulked and made water-tight, the pitch, or distance from centre to centre, of the rivets should not exceed from four to five diameters in the rows adjacent to the joints; but when it is a question merely of connection between plates and stiffeners—as between the outside plating and the frames, or the deck-plating and the beams—then the pitch may be made about twice as great—say from seven to nine diameters. There are, however, other questions in connection with the pitch of rivets, particularly as regards butt-fastenings, which are by no means free from difficulty or discussion; and hereafter we shall refer to them more fully.

Experiments have been made to determine the tensile strength of rivet-iron, and also its *shearing* strength—*i.e.*, the force required to cut the iron across at a section perpendicular to the length of the bar. It appears that the shearing strength is a little less than the tensile strength; but this fact is not of any great practical value in making arrangements of riveting, because it is well established that the iron in the finished rivet is less strong than that in the bar—having suffered somewhat from the usage to which it is subjected in its manufacture, knocking-down and cooling—and also because of the fact that the contraction of the rivets in cooling necessarily causes considerable friction in a joint, and so adds to its strength to resist tensile strains. Our meaning will be more clearly understood if we suppose the tie-plate shown in Fig. 10 (Vol. III., page 30) to be subjected to tensile strains, tending to tear the butt asunder. If instead of finished rivets in the butt-strap we had merely pegs of rivet-iron passed through the holes, and were careful to keep the straining force exactly in the line of the tie-plate, then it would only be necessary to shear off these pegs, in order to open the butt. But when finished rivets are put in, friction is caused by their contraction at the surfaces of the strap and plate, and then in order to open the butt it is necessary to overcome this friction, as well as to shear off the rivets. The shearing strength of the rivets would no doubt be less than that of the supposed pegs of rivet-iron; but taking into account the friction, the strength of the butt would be increased. In practice we do not require to separate the frictional resistance from the shearing strength of the rivets, but rather need to know something definite as to the strength of riveted joints, with finished rivets. Mr. Reed supplies us with some facts which exactly meet this necessity, stating, as the result of experiments made at Chatham Dockyard, that the "mean shearing strength of a $\frac{3}{4}$-inch rivet passing through two plates was ten tons, and the mean of the double shearing strengths of a $\frac{3}{4}$-inch rivet passing through three thicknesses was about eighteen tons." These experiments were made under fair representative conditions as to pitch of rivets, breadths of lap, etc., and form reliable data for calculation. It is probably near the truth to assume that for finished rivets of other sizes the strengths would compare with that of the $\frac{3}{4}$-inch rivet as the *squares of the diameters* compare; for example, that for a 1-inch rivet:—

For single shear—

Strength : 10 tons : : $(1)^2 : (\frac{3}{4}^2)$;

Whence—

Strength $= \frac{160}{9} = 17\frac{7}{9}$ tons.

And for a double shear—

Strength : 18 tons : : $(1)^2 : (\frac{3}{4})^2$;

Whence—

Strength : 32 tons.

It will perhaps be worth adding that a simple illustration of what is meant by a *double shear* may be obtained by supposing that a second butt-strap is fitted above the plate-tie in Fig. 10 (Vol. III., page 30). Before the butt could then be opened, the parts of the rivets lying between the straps would have to be dragged away with the plates, and so there would be a *double* shear. Hereafter we shall see how valuable a method this double strapping is in securing the butts of some pieces of an iron ship.

Before concluding this article, we would draw attention to a simple but important fact, which has an important bearing upon the proper arrangement of butt-fastenings in an iron ship—viz., that in all cases the pieces butted have unavoidably weakened sections, the strength of which should regulate that of the butt-fastenings. For example, if we take the simple case of a deck stringer-plate (similar to that shown in Fig. 56, page 37), we find rows of holes punched to receive the rivets securing the stringer to the beams, and in wake of these holes weakened sections must occur. Or if we turn to any assemblage of plating, such as the outer skin, we find similar weakened sections existing in wake of the transverse frames and stiffeners. These weakened sections might, of course, be made stronger by means of broad liners; but this plan would lead to costly workmanship, and does not recommend itself for adoption, except in special cases, such as in wake of water-tight bulkheads. Ordinarily, stringers, ties, and assemblages of plating are left without additional strengthening at the weakened sections in wake of the stiffening pieces, frames, beams, vertical and horizontal bars, etc., and as a consequence it is only necessary to give to the sections in wake of the butts an amount of strength equal to that of these weakened sections. If more strength is given, an additional and useless expenditure of money, time, and material is incurred, and it is folly to attempt to make the strength in wake of the butts as great as that at sections where the plating is left unpunched.

Stress is laid upon these considerations, because, simple as they are, they have been overlooked by some persons who have done much to advance wrought-iron construction; and as a result, deductions made from experiments on simple plate-ties (such as are illustrated by Figs. 9 and 10, Vol. III., page 30) have been applied, without correction, to the very different combinations of plating in the structure of an iron ship. Heavy and expensive arrangements of butt-fastenings have come into use in consequence; but such fastenings are worse than useless, and the fact is now very generally acknowledged.

FORTIFICATION.—XII.

By An Officer of the Royal Engineers.

TYPES OF PERMANENT DEFENCES—BASTIONED SYSTEM—POLYGONAL SYSTEM—FORTIFICATIONS OF ANTWERP.

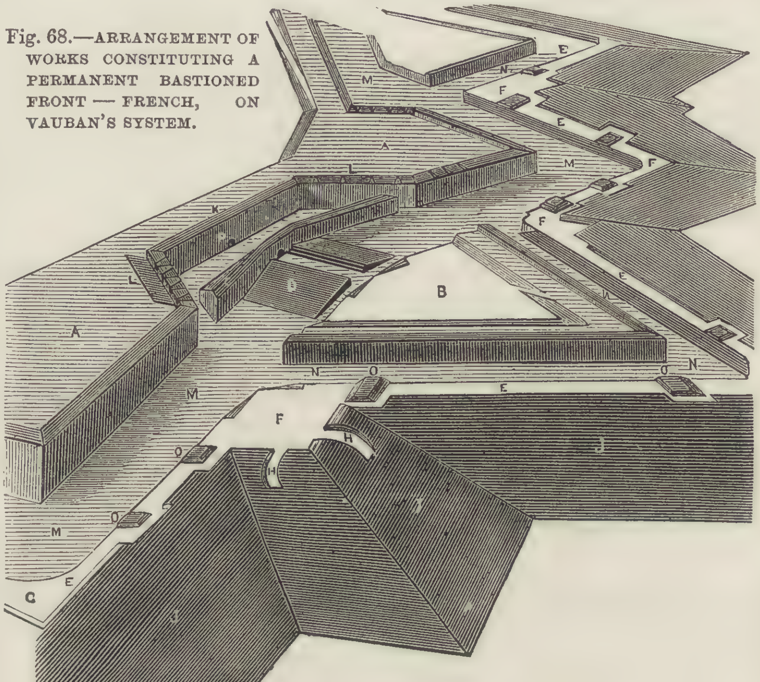
Anything like a thorough investigation of the various systems of permanent fortification still existing in Europe would be a work of considerable time and labour, without having for the generality of students any practical advantage. Many of these systems are now obsolete, and were designed for warfare under totally different conditions to those of the present day; there is, therefore, little beyond a certain historical interest attaching to them, and they will only be referred to in order to explain the uses of such of their details as may still be retained in the more recently constructed European fortresses.

We find that the types of permanent defences have succeeded one another at longer or shorter intervals as the science of artillery progressed and the occasion for building fortresses occurred.

Thus, during the wars of France in the sixteenth and seventeenth centuries, when a large number of towns were strengthened and besieged, the systems previously employed were considerably extended and improved; and again after 1815, when the Germans had occasion to strengthen their frontier, they sought to avoid the defects of the bastioned system by adopting the suggestions of Montalembert, and thus entirely changed the type of their works. Prior to the introduction of artillery, the main enclosure or *enceinte* of a fortress consisted of a high masonry wall, high enough to be secured from escalade, and sufficiently thick to resist the action of battering rams and other engines employed in the sieges of that period. The fighting of the defenders was carried on behind a loopholed parapet at the top of this wall, which was flanked by towers placed within bow-shot of one another. These towers were originally round or square in plan, and of no very great size, but under the new conditions it became necessary to make them larger, so as to allow of parapets being constructed of earth instead of masonry, and they were placed further apart to suit the increased range of fire-arms.

The Italian engineers, as early as 1530, adopted the pentagonal or bastion shape for these towers, from the facility they afforded for reciprocal flank defence, and hence arose the various systems known as bastioned systems, which underwent various modifications at the hands of Vauban (1650), Cormontaigne, and other celebrated engineers, and are now to be found in all the French and in numerous other Continental fortresses. The system of fortification which has, however, lately become the favourite type, as being most adapted to the changed conditions of war, was, strange to say, advocated as early as 1527, in a work on fortification by Albert Durer, at Nuremburg, as well as by Martini, an Italian, about the same date. It was first adopted in Germany early in the present century, and has subsequently been employed in Belgium, and in the more recently constructed forts for the protection of the English dockyards.

Fig. 68.—ARRANGEMENT OF WORKS CONSTITUTING A PERMANENT BASTIONED FRONT — FRENCH, ON VAUBAN'S SYSTEM.



Explanation of References.

A A, Bastions.	G G, Salient places of arms.
K K, Curtains.	H H, Sally-ports.
L L, Flanks.	J J, Glacis.
B B, Ravelins.	M M, Main ditch.
C C, Tennaille.	N N, Ditch of ravelin.
D D, Caponièrre.	O O, Traverses in covered ways.
E E, Covered way.	P P, Postern.
F F, Re-entering places of arms.	

The chief characteristics of this system of fortification, which is called the "polygonal system," are, that the lines of parapet are traced with reference to the space they have to enclose, and the direction from which it is probable an attack would be made, and not with reference to the reciprocal flank defence of the ditches, which are entirely defended by casemated masonry buildings in them, called kaponiers, or by reverse galleries placed in the counterscarps at the salients.

There are various minor differences, both as regards the profile and the arrangements of the outworks, which exist between the two systems, and which will be referred to hereafter; but before examining these details, the names and uses of the following portions of a permanent fortress should be understood:—

The *enceinte*, or "body of the place," is the main enclosure of the fortress, and usually consists of an earthen embankment or "rampart," and a deep ditch with a revetted escarp and counterscarp.

The *rampart* should be of sufficient height to enable the guns on it to thoroughly command the whole of the ground within range, and wide enough to carry a parapet at least twenty-five feet thick, as well as allowing ample room for working the guns and the other operations of the defence.

The *ditch* of a permanent work provides the earth to form the rampart, and must in itself be a formidable obstacle. In low, marshy sites, the ditches are usually filled with water, and are made of considerable width, but not more than ten or twelve feet deep, which is sufficient to oblige the enemy to construct rafts or bridges to cross them. In other positions where water is not found near the surface, the ditches will be dry, and must be of such depth, that even with the use of long scaling ladders the operation of crossing them is very difficult and slow, while the breadth must allow of their being flanked by a battery of several guns. So long as this last condition is fulfilled, it may safely be affirmed that the deeper and narrower a dry ditch is, the stronger the work will be, as the escarps will be better covered and the difficulty of escalade greatly increased. As a rule, wet ditches are not revetted, whereas dry ditches are, and the heavy expense of revetment walls is saved in cases where the former can be employed. In some situations—as, for instance, where a river flows through a fortress—it is possible to combine the advantages of both wet and dry ditches without the defects of either. This is managed by means of sluice-gates, which enable

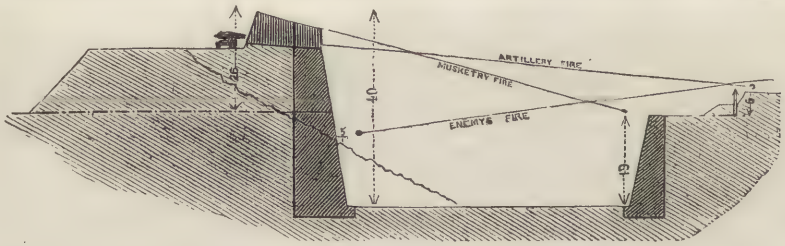


Fig. 69.—SECTION THROUGH BASTIONS OF VAUBAN'S FIRST SYSTEM, SHOWING THE LIABILITY TO BE BREACHED BY ENEMY'S ARTILLERY.

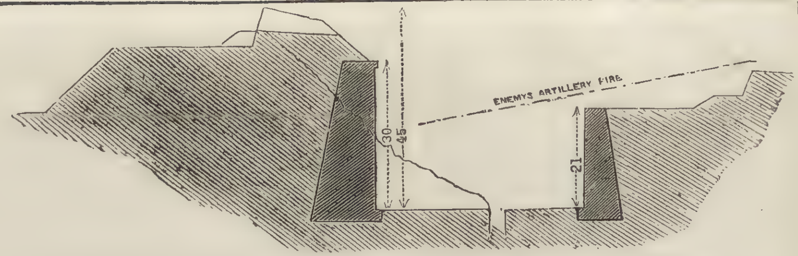


Fig. 70.—SECTION THROUGH BASTION IN MODERN FRENCH SYSTEM.

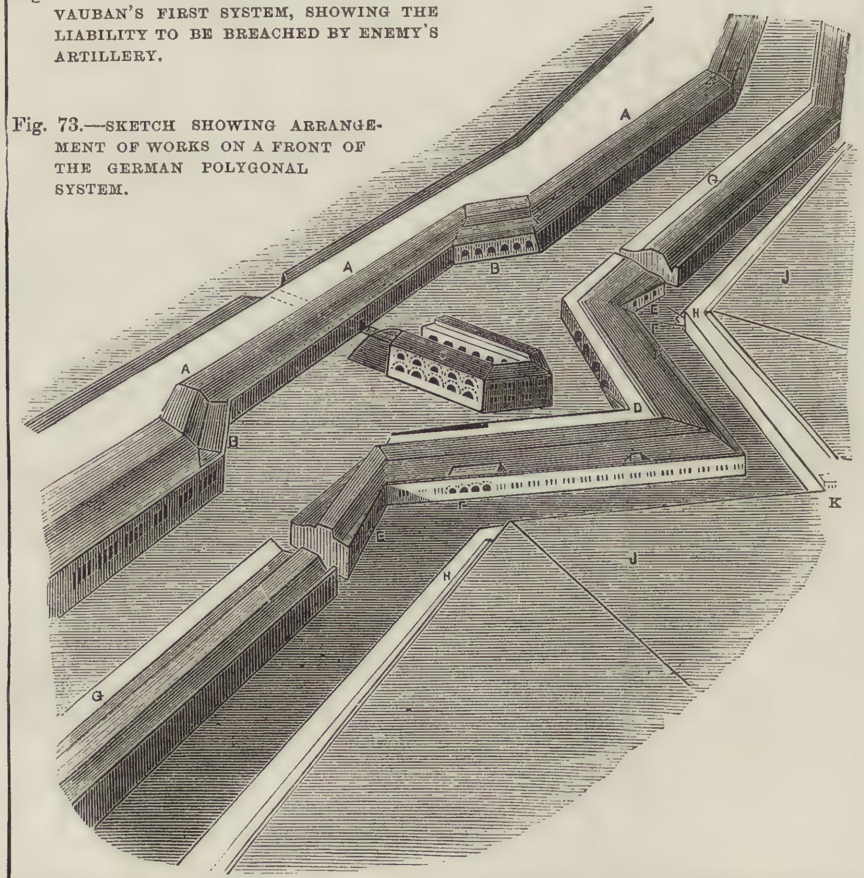


Fig. 73.—SKETCH SHOWING ARRANGEMENT OF WORKS ON A FRONT OF THE GERMAN POLYGONAL SYSTEM.

EXPLANATION OF REFERENCES IN FIG. 73.

A A, Body of the place.
B B, Casemated flanks to defend ditch of kaponier.
C, Casemated kaponier, two tiers of 5 guns.
D, Ravelin.
E E, Casemated flanks to defend ditch of ravelin.
F F, Casements in ravelins to defend ditch of counter-guard.
G G, Counter-guard.
H H, Covered way.
J J, Glacis.
K, At the salients of the covered way there are often masonry block-houses flanking it, and acting as a traverse.

Extent and Position of the Enemy's Batteries.

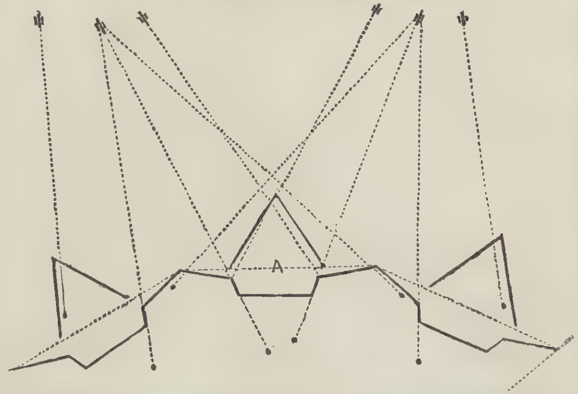


Fig. 71.—SKETCH SHOWING LIABILITY TO ENFILADE IN THE BASTION SYSTEM.

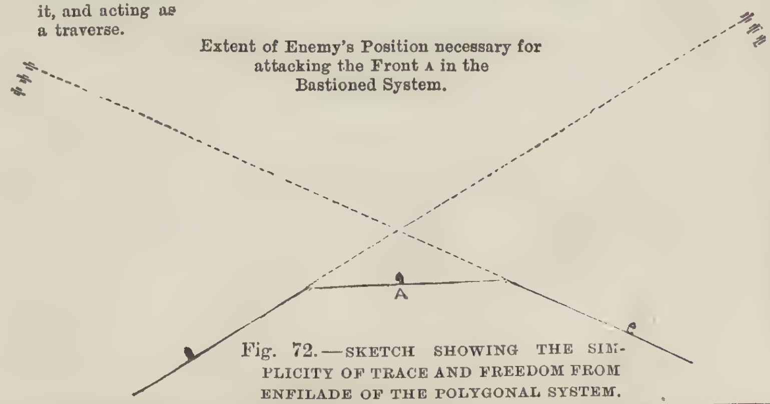


Fig. 72.—SKETCH SHOWING THE SIMPLICITY OF TRACE AND FREEDOM FROM ENFILADE OF THE POLYGONAL SYSTEM.

the defender to flood his ditches at pleasure, and gives the defence a great advantage, since the passage of a wet ditch with a current through it is perhaps the most difficult operation of a siege; while, on the other hand, it is a great convenience to the garrison to keep the ditch dry as long as possible, as they can cross the ditch where they please, instead of being restricted to certain bridges only, which may be damaged or destroyed at any time.

Outworks are additional works placed outside the ditches of the enceinte, but within the glacis. The principal outwork of a modern front of fortification, in either of the systems, is a "ravelin," or large redan, placed in front of the centre of the exterior side. It has usually a revetted ditch, and is useful as affording an advanced position for artillery to flank the glacis and enfilade the enemy's trenches. In the bastioned systems the ditches of the ravelins are flanked by guns in the enceinte, and in the polygonal system by guns in low casemated batteries in flanks attached to the ravelins themselves. They should be large works, of strong profile and considerable saliency, in order to compel the besieger to direct his approaches very obliquely towards the place. Their liability to enfilade is their chief defect, which must be met by special arrangements—traverses, etc. etc. In "Dufour's system," which is one of the many bastioned systems of comparatively modern date (1822), an attempt is made to check enfilade by a cavalier or high mound of earth at the salient of the ravelins; and in the systems by Choumara (1827), and in General Brialmont's great fortifications at Antwerp, this difficulty is met by making the trace of the crest of the ravelins quite independent of that of the ditch, and breaking it into several short faces.

"Counterguards" are outworks whose primary object is to screen the escarps of the ravelins and enceinte from being breached. Their trace follows that of the works they have to protect, openings being made in them at the re-entering angles to allow of their ditches being flanked. In the German systems they are flanked by guns in casemates under the faces of the ravelins.

"Advanced works" are those which are occasionally added to the ordinary works of a permanent front to ensure the defence of ground which would not otherwise be brought under fire. They are usually open works beyond the glacis, but within easy range of the guns in the enceinte. Horn works and crown works belong to this class, and may be found in many of the older fortresses.

"Retrenchments" are works constructed within others with a view to isolate the parts most liable to be first taken, and thus prolong the defence of the fortress. In the bastioned systems retrenchments are extensively provided, both in the bastions of the enceinte and in the ravelins, portions of the faces of which are isolated by a small ditch and parapet at right angles to the face, called a *coupure.*

An outwork termed the "redoubt of the ravelin" exists in most of the bastioned systems. It is a small lunette within, but separated from the ravelin by a ditch, and serves as a species of retrenchment to it as well as being useful in bringing a reverse fire to bear on that portion of the bastion face most likely to be breached.

A "cavalier" is a high work having sufficient command to allow its guns to fire simultaneously with those of the works in front, and to bring a plunging fire to bear on the enemy's lodgments on the glacis. A cavalier frequently is made to contain a bomb-proof barrack or principal magazine, and when isolated from the rest of the works by a ditch, is often made use of as a retrenchment.

Bastions are termed "full" when the interior is level with the terre-plein of the rampart on either side of it. Empty bastions are those in which the interior is at a lower level than the ramparts. These latter have the defect that the space available for constructing traverses, parados, etc., during a siege, is much more cramped than in the others.

The "covered way" is a passage usually about eleven yards in width between the glacis and the edge of the counterscarp. It is about eight feet below the crest of the glacis, and is provided with a banquette for musketry, and with traverses to check enfilade. It serves as a useful means of communication between various parts of the works beyond the ditch, enables the defenders to assemble in numbers before making sorties, and by giving cover to the advanced sentries affords great security against surprise.

Casemates are arched bomb-proof chambers intended as a protection from vertical and enfilade fire. They are used as barracks, as magazines, and also in some situations for guns. In a gun casemate, the embrasure is made in the end wall of the casement, and unless this wall is constructed of iron (as is the case with the Spithead Forts, Portsmouth), it will be rapidly demolished by direct artillery fire. Gun casemates are therefore more frequently employed in the flanks of works and in the flanking batteries of the ditches, where the liability to be counterbattered by artillery is remote.

When the guns on the ramparts of the flanks of a work are protected by casemates, these latter are generally arranged on the plan suggested by Baron Haxo, a French officer (1826), which consisted in protecting as much as possible of the front wall of the casemate by an earth merlon, right and left of each embrasure. Casemates à l'Haxo are very generally used in the flanks of the English and Belgian forts, and also in the lower tier of the kaponiers at Antwerp (Fig. 78). The protection afforded by this arrangement is, of course, only partial, and eventually the embrasure will be destroyed and the guns silenced. The defence may, however, be greatly prolonged by constructing a larger number of casemates than are required for the guns intended for simultaneous firing, the spare casemates being entirely hidden by the earth merlons. By this arrangement, which exists in the kaponiers at Antwerp, as soon as a gun is disabled a very little work will suffice to unmask the new casemate, and leave the defence of the ditch unimpaired.

Kaponiers are large casemated masonry buildings for the defence of the ditches of permanent works on the polygonal system. The ones generally seen in the German works are detached from the escarps and constructed in two storeys, the number of guns in each tier depending on the breadth of the ditches. The addition of a second gun-floor greatly increases the power of the kaponier, and gives it a superiority of at least two to one over the enemy's counter-batteries, which must towards the end of the siege be erected near the salients of the covered way, unless they are able to silence the kaponier by distant fire. At the same time it must be remembered that by adding a second storey to the kaponier, the amount of exposed masonry is greatly increased, and it becomes almost impossible to protect it from the effects of curved fire. In the detached forts that have been constructed in England, the kaponiers have as a rule only one gun-floor, and consequently are lower, and therefore much less liable to be damaged by distant artillery fire. The English kaponiers are generally attached to the escarps, and placed at the angles of the ditches, whereas in the German works the kaponiers are generally detached, and are situated in the middle of each long face.

The communication to the kaponiers is by means of a tunnel leading from the interior of the works. When such a tunnel serves as the means of access to the ditch and outworks, it is called a postern, the entrance to it being closed by a drawbridge.

Mortar casemates are vaulted chambers without a front wall, employed in many modern works to secure the mortars of the fortresses from vertical fire, and so placed that the fire from them can be brought to bear on those parts of the glacis over which the advance of the attack will be made. In modern sieges there is little doubt that the attempt to advance against a place must be disastrous, unless the artillery direct defence has been previously annihilated, and there is also no doubt that in time this result will be obtained with the numerical superiority of guns, and the concentrated fire which the besieger is able to oppose to the smaller front of the besieged, and after the attack has once established its supremacy, any fresh development of artillery defence must needs be but very partial, and easy to be silenced by a repetition of the first bombardment. It is under these circumstances that mortar casemates are of great use. Placed behind the rampart of the enceinte, unseen by the enemy, and very difficult to strike, they command the field of attack at the salients, and by a well-directed shower of large shells must greatly increase the difficulties of the attack, which would otherwise only have musketry and mitrailleuse fire to deal with. They are employed in the German systems, and in some of the English forts. It is, however, a question whether the protection afforded against vertical fire is worth the cost, since mortars in these positions with earth traverses between them would be nearly as efficient, while the expense of preparing for them would be much less. Their use was first

advocated by Virgin, a Swedish engineer, in 1780, and subsequently by Carnot.

A *tennaille* is an outwork in front of the curtains of the bastioned systems, and is given as a parapet for the musketry defence of the ditch. Its chief use, however, is to act as a counter-guard, and protect the postern and escarps of the curtain and flanks from being breached. In works with dry ditches it facilitates sorties against the besiegers at the moment they are trying to assault and storm the breach, as the defenders can assemble in considerable numbers in the space between the tennaille and curtain.

A *caponnière* is a low work consisting of two glacis parapets, which serve to cover the communication across the main ditch between the tennaille and the ravelin of a bastioned front.

The terms "salients" and "re-entering places" of arms are given to the enlargements of the covered way, which are made at the angles formed by the ditches. The re-entering places of arms are useful, as affording space for assembling troops for making sorties, and points from whence the possession of the covered way may be disputed. In Vauban's first system a traverse is placed on either side of the re-entering place of arms, which converts it into a species of redoubt; and in almost all the other bastioned systems this idea is still further carried out, the re-entering place of arms being made larger, to admit a regular redoubt with a ditch being constructed within it.

The names and uses of the principal parts of a fortress having now been mentioned, we must consider what conditions the profile of a permanent work should fulfil, and how far they are carried out in the two main systems under consideration.

1st. The glacis of the fortress should be swept by both the artillery and musketry fire, and, moreover, the latter should be able to thoroughly command the covered way and interior of the outworks. To effect this, the musketry fire is usually arranged so as to strike a point about three feet above the top of the counterscarp.

2nd. The ditch should be a really formidable obstacle, which, in dry ditches, implies a counterscarp of twenty feet, and an escarp thirty feet high, the width of the ditch being dependent on the flanking arrangement and the fulfilment of the last condition.

3rd. The escarp must be screened not only from view, but also from the enemy's fire. Where the flanking defences have been silenced, and the approaches of the attack have arrived at the crest of the covered way, the escarp is (in a dry ditch) the only serious obstacle in the way, as the counterscarp wall can in a short time be blown in by mining, and the assaulting troops admitted to the ditch of the fortress.

The accurate curved fire and large shells of the present day give such facilities for breaching a wall from a distance, that not only must the ditches be made narrower than heretofore, but deeper, so that the top of the escarp wall shall be some ten or fifteen feet lower than the crest of the glacis. This plan has been adopted in the profile of the English forts, and the tendency towards this may be observed by noticing the difference between the profile of the earlier works (Vauban, Fig. 69), the subsequently improved profile of the modern French system (Fig. 70), and that of the English works (Fig. 76).

The escarp wall of a fortress must necessarily be high, massive, well built, of very considerable length, and therefore a very expensive item. It may either be attached to the rampart, and serve as a revetment to the earth behind it, or may be a detached wall, as in the German system (Fig. 73). A detached escarp is sometimes called a "Carnot wall," from the name of the French officer who proposed its adoption about 1810. Escarp revetments are termed "full" when the masonry is carried up to the superior slope. "Demi-revetments" are those in which the top of the masonry is at the level of the berm or foot of the exterior slope. "Chemin des rondes" is a demi-revetment advanced a sufficient distance in the front of the foot of the exterior slope to allow a passage between it and the slope. This has many advantages. 1st. If the upper part of the escarp is breached, it does not necessarily bring down with it the earth from the parapet. 2nd. A secure place for sentries is provided from whence they can see into the ditch, and prevent a surprise. 3rd. From it an additional line of musketry defence can be brought to bear on the enemy in the covered way and ditch, and during the siege working parties can assemble in it, and repair the damages done to the slopes. A small parapet wall is usually added to the ordinary demi-revetment wall (*vide* Fig. 75) in a "chemin des rondes." Escarp walls are either built solid or in a series of arches, the fronts of which are built up to hide the position of the piers. In the former case they may be either "leaning"—*i.e.*, when both front and back of the wall slope inwards towards the parapet; "sloping," in which case the only front of the wall is built at a batter or inclination; "counter-sloping," where the front of the wall is vertical, and the back of it slopes from a broad base to a minimum thickness at the top. The wall suffers less from the action of the water, and the growth of weeds in the joints of the masonry, when built with a vertical than with a sloping face: hence counter-sloping revetments are preferred.

In counter-arched revetments the earth is carried on the arches, and its lateral thrust against the wall is avoided. The arches are usually in two tiers, the space beneath them being sometimes converted into a gallery with loopholes through the escarp for musketry fire. Such galleries are termed escarp or counterscarp galleries, and are frequently employed in both the German and English works as a means of flanking the kaponiers and defending the ditch.

As regards safety from breaching, the detached wall in the German system has an advantage, as without altering the width of the ditch or the relative levels, it can be better protected by placing it nearer to the counterscarp; whereas in the bastioned systems, the escarp must follow the outline of the rampart, and the ditch must either be reduced in width or the glacis raised considerably, which would probably involve an increased command to enable the guns on the terre-plein of the rampart to defend the ground outside.

The general idea of the works of a front as arranged by Vauban is given in Fig. 69, and although the actual dimensions he adopted were designed for the fire-arms of 1650 and are now obsolete, yet the main arrangements of his system have been retained, and form the basis of all the modern French systems which may be seen at Paris, Metz, Lille, etc. etc.

The improvements that have been made on the original type consist, as regards trace, in—

1st. Larger and more salient ravelins, large enough to admit an inner redoubt.

2nd. Better flanking angles for the bastions of the enceinte.

3rd. Redoubts in the re-entering places of arms.

4th. Escarps of bastions better covered, by making the ditches of the ravelins shallower, and constructing traverses across them. These traverses are also of use in covering the communication to the covered way.

5th. Redoubts in the re-entering places of arms, and coupures in the ravelins.

The improvement in profile from the "full" to the "demi" or the "chemin des rondes" revetment has been already alluded to.

One of the most important defects of the bastioned systems, as compared with the polygonal trace, is the liability of the former to suffer from enfilade and reverse fire. In the present day, when elongated rifled shot do not ricochet with such certainty along the line of fire as the old spherical projectiles, the effect of enfilade fire may be less than formerly; but if so, the power of shells has on the other hand greatly increased, and the disadvantage to the defenders of works so traced as to be liable to enfilade or reverse fire will be keenly felt.

The bastions of Forts Issy and Vanves in Paris, and some of the bastions of the Paris enceinte suffered in this way, and one has only to glance at the complication of traverses that were thrown up in the hopes of checking this, to be quite certain of this grave defect inherent in the system. In Fig. 72 the advantages possessed by the more simple trace of the polygonal over the bastioned trace are shown.

Fig. 73 gives a general idea of the arrangement of works usually adopted in the German fortresses. It must not, however, be supposed that this exact combination is to be found in every case, for though built on the same principles, there are so many details dependent on the site, and also on the finances at the engineer's disposal at the time, that very few fronts and certainly no two fortresses will be found exactly similar.

The head of the kaponier is flanked by casemates in the escarp of the enceinte, while the ditches of the ravelins and counterguards are defended by similar casemates in the ravelin. Mortar casemates and bomb-proof cover generally are also a distinguishing feature of the system, as is the detached or semi-detached loopholed escarp wall already alluded to. This wall

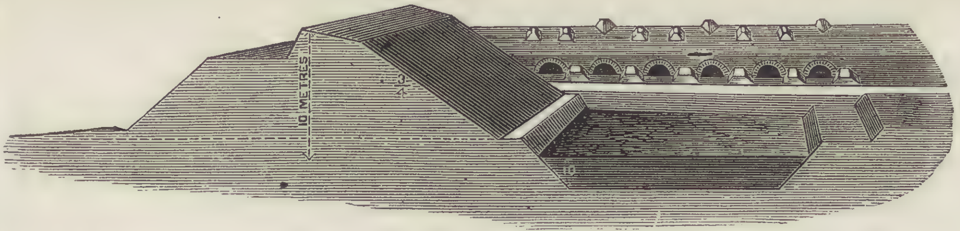


Fig. 78.—SECTION THROUGH ENCEINTE AT ANTWERP, SHOWING MAIN KAPONIER.

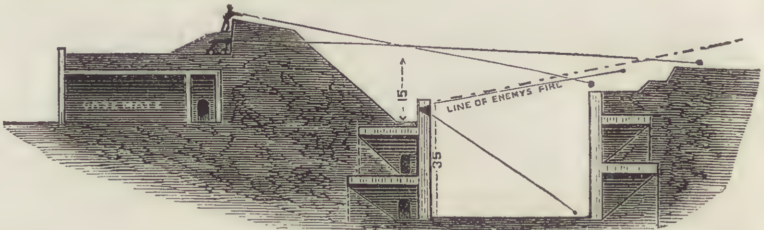


Fig. 76.—TYPE OF THE SECTION ADOPTED IN ENGLAND—COUNTER-ARCHED REVETMENTS AND CHEMIN DES RONDES.

Fig. 74.—GERMAN SYSTEM—DETACHED ESCARP WALL AND COUNTERSCARP GALLERIES.

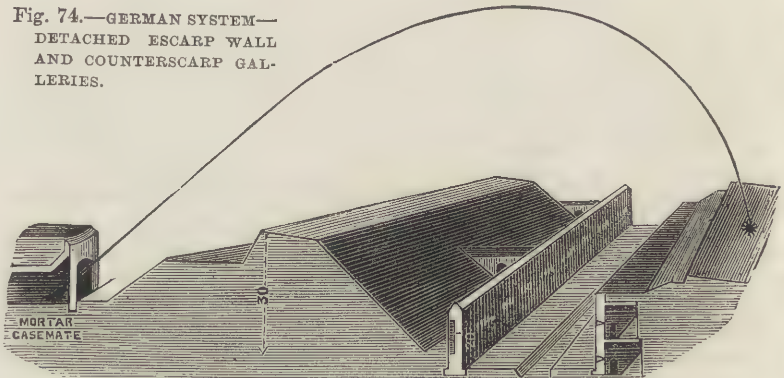
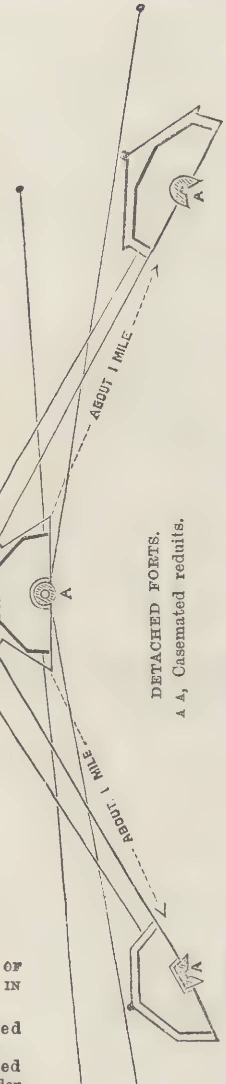
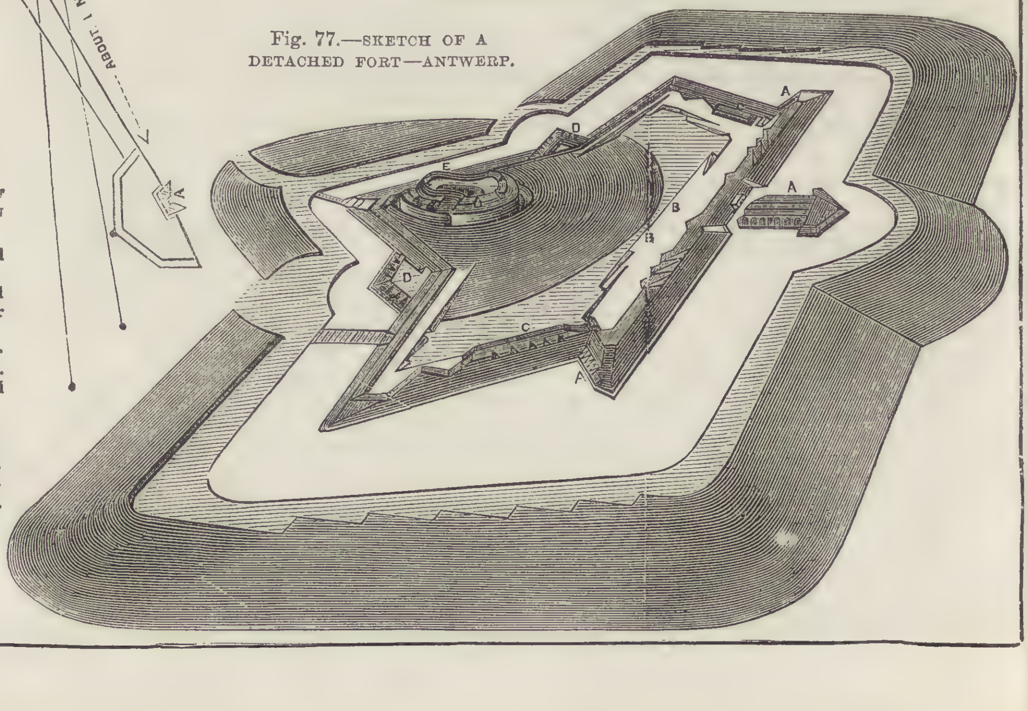


Fig. 75.—SKETCH SHOWING THE ARRANGEMENT OF WORKS CONSTRUCTED IN ENGLAND FOR THE PROTECTION OF THE DOCKYARDS.



DETACHED FORTS.
A A, Casemated reduits.

Fig. 77.—SKETCH OF A DETACHED FORT—ANTWERP.



EXPLANATION OF REFERENCES IN FIG. 77.

- A A, Casemated kaponier.
- B B, Casemated barracks under rampart.
- C C, Haxo casemates on flanks.
- D D, Low level batteries.
- E, Casemated reduit, surmounted in some cases by an iron turret for two guns.

secures the place against surprise, brings a close fire on the bottom of the ditch, and when breached does not bring down with it a large mass of earth to block up the ditch and impede the fire from the flanks and kaponiers. Wrought-iron palisades or high railings have been proposed of late years in Germany as a substitute for this wall.

In England there are very few fortresses or fortifications of any kind except mere coast batteries, and the newly-constructed detached forts at our principal naval dockyards. In arranging the defence of the dockyards, the two antagonistic conditions of a long line to defend, and a minimum number of defenders, had to be reconciled. An enemy having once landed in England, the whole of the regular troops, as well as a large body of militia, would be required for the field army, and the defence of the dockyards would devolve upon a relatively small number of reserves, and on the garrison and marine artillery. The object of the works is to prevent the enemy either taking them easily or passing between them, and at the same time to render it impossible for him to burn the dockyards by a distant bombardment. The enormous range of rifled guns obliged the circle on which the guns are placed to be a very large one, with a radius of not less than 4,000 or 5,000 yards, and the necessity of preventing an enemy in force passing between them rendered it advisable to place them within easy artillery range of one another. The works are thus mutually supporting, and form as it were a series of closed bastions, no one of which can be attacked without engaging two or more collateral forts. The intervals between the forts can easily be further strengthened by batteries and field-works placed somewhat in rear of the main line. As compared with Continental examples of detached forts, they are small, being intended for defence by small bodies of troops; their profile, however, is a formidable one, calculated to enable them to make an obstinate resistance (Fig. 76).

The independent trace of the parapets and ditches, kaponier defence, Haxo casemates in the flanks, considerable casemated accommodation, and a casemated keep or "reduit" serving as barrack in time of peace, form the chief characteristic of the English detached forts.

The magnificent new fortifications of Antwerp are probably the most complete and interesting modern works in Europe. A level site, and an almost unlimited vote, have enabled General Brialmont to construct a most formidable and extensive enceinte, strengthened by a circle of detached forts at a distance of about 2,000 mètres in front. This combination of a continuous enceinte with a cordon of forts is undoubtedly the strongest type of defence, if it can be carried out on a sufficiently large scale, and may be found at Paris, Metz, Lyons, Cologne, Coblentz, Mayence, and other first-class fortresses. The object of the forts is to prevent or postpone the bombardment until after they are taken, after which the regular siege would begin while the enceinte would prevent the enemy forcing his way through, and investing or cutting off each fort from its supplies, etc. At Antwerp, the ease with which a large extent of the surrounding country can be inundated, and the distance of the enceinte from the town, render it an exceptional case, in which the character of the site has been fully taken advantage of, and in which both the principles and details of the polygonal system, as adapted to modern requirements, have been most admirably applied. The section of both the enceinte and detached forts is very similar (Fig. 78). The detached forts themselves, of which Fig. 77 gives a general idea, are much larger than the corresponding works in England, and are connected by a military road under cover of a parapet. Batteries are intended to be constructed in the intervals between the forts, and both a railway and telegraph would be employed to facilitate communications between them.

The experience of the late war has shown that if fortresses are to be of any real importance in future, they must be completely armed, provisioned, and adapted to modern warfare, not merely capable of resisting for a certain time on the front attacked, but of withstanding the heaviest bombardments. To do this bomb-proof cover in immense extent must be provided, far in excess of the peace requirements of the garrison, and no buildings on any account whatever should be allowed near the works. Buildings, however small, within 2,000 yards of the works, would, if in front, have to be pulled down, and even then their ruins would give cover, and if behind the forts, they are sure to draw on their inhabitants the horrors of a bombardment. Were it possible to obtain it, a model fortress should contain no buildings that could suffer from the enemy's fire, nor a population of any but soldiers for its defence, and in future sieges the most humane governor of a fortress will be the one who has the courage to ruthlessly expel the whole non-combatant population before the siege begins, rather than he who, out of compassion for their helplessness, allows them to remain and ultimately become the victims of famine and bombardments. The Russian fortress of Modlin, near Warsaw, is perhaps the nearest approach to this type in Europe.

The study of permanent fortification is a deep and complicated one, and it has, therefore, been impossible to do more than treat it here in a very superficial manner. The best books on the subject are, perhaps, "History of Fortification" (German) by Zastrow; "Défense des États," by General Brialmont; and numerous works in French by Noizet de St. Paul, Bousmard, Chasseloup de Laubat, Montalembert, Haxo, Choumara, etc.; while the works in English by Sir H. Douglas on "Modern Systems of Fortification," by Captain Philips, R.E., Captains Lendy and Straith, as well as numerous articles on the subject, which have appeared in the Royal Engineers Professional Papers, should be studied by any one anxious to master the subject.

PATENTS AND PATENT LAW.—IV.

By A Barrister.

THE RIGHTS AND PRIVILEGES OF A PATENTEE.

Having obtained a patent, what rights become vested in the patentee? Several provisions of great importance have been introduced into the various Acts of Parliament for the purpose of protecting patentees. And, first, to protect them in the possession of their patent it is provided that if, after a patent has been granted to a person on the ground of his being the first inventor, it is discovered that some other person had in fact preceded him in the use of the invention, though the article was, at the time of the grant, not generally known to the public, the acts enable the patentee or his assigns to petition Her Majesty in Council for a new grant, or a confirmation of the existing one; and if the Judicial Committee of the Privy Council shall, upon investigation of the case, report in his favour, such relief may be lawfully awarded (5 & 6 Wm. IV., c. 83, s. 2). And we have already referred to the process of disclaimer by which any error in the title or specification may be rectified.

The actual rights and privileges which the patentee possesses under the letters patent will be best understood by a reference to the form of the letters patent, which runs thus:—"Know ye therefore that we, of our especial grace, certain knowledge, and mere motion, have given and granted, and by these presents for us, our heirs and successors, do give and grant, unto the said A B, his executors, administrators, and assigns, our especial licence, full power, and sole privilege and authority, that he the said A B, his executors, administrators, and assigns, and every of them by himself and themselves, or by his or their deputy or deputies, servants or agents, or such others as the said A B, his executors, administrators, or assigns, shall at any time agree with, and no others, and from time to time, and at all times hereafter, during the term of years herein expressed, shall, and lawfully may make, use, exercise, and vend his said invention within our United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, in such a manner as to them may seem meet." To avoid further use of formal expressions, we may state that the letters go on to secure to the grantee and his assigns "the whole profit, benefit, commodity, and advantage, from time to time coming, growing, and accruing, and arising," by reason of the invention; to the end that "they may have and enjoy the full benefit and the sole use and exercise" of the invention. Then follows a prohibition directed to all other persons and bodies corporate, commanding them neither directly nor indirectly to make, use, or put in practice the invention or any part of it, nor in any wise counterfeit, imitate, or resemble the same, nor make or cause to be made any addition to or subtraction from the same, whereby to pretend himself or themselves the inventor or inventors, devisor or devisors thereof, without the consent, licence, or agreement of the patentee.

From the foregoing it will be seen that the patentee may either assign or grant a licence to use his invention. It seems

doubtful whether it is necessary that letters patent should be assigned by deed. Mr. Joshua Williams, a very eminent lawyer, says, "A deed is said to be necessary for the valid legal assignment of letters patent; but the author is not aware of any authority for this position; and the general rule appears to be that the assignment of incorporeal personal property may be made without deed. Perhaps, however, the necessity of an assignment by deed may be implied from the clause in the letters patent which forbids the use of the invention without the consent, licence, or agreement of the inventor, his executors, administrators, or assigns, in writing, under his or their hands and seals, first had and obtained in that behalf." ("Personal Property," 7th edit., p. 223.)

All assignments of letters patent are now required to be registered under the Patent Law Amendment Act, 1852, which provides that a "Register of Proprietors" shall be kept at the office for filing specifications in Chancery. In such register must be entered the assignment, or any share or interest, any licence under letters patent, and the district to which such licence relates, with the name or names of any person having any share or interest in such letters patent or licence, the date of his or their acquiring such letters patent, share, and interest, and any other matter or thing relating to or affecting the proprietorship in such letters patent or licence. Until such entry has been made, the grantee or grantees of the letters patent will be deemed and taken to be the sole and exclusive proprietor or proprietors of such letters patent, and of all the licences thereby given and granted.

It may here be convenient to refer to the divisibility of a patent, and it would seem that there is no legal objection to the assignment of part of a patent. By the Act of 15 & 16 Vict., c. 83, s. 36, it was made lawful for a larger number than twelve persons to have a legal and beneficial interest in letters patent. A question has arisen on this, whether the shares of such persons are shares in the profits only or so many rights of property, and consequently so many rights to sue for an infringement. This important subject was discussed by Chief-Justice Erle, in his judgment in the case of Walton *v.* Lavater. It was contended in that case that a grant under letters patent is a one and individual franchise, and that by the assignment of the moiety the whole of the patent remains in the original patentee, but that the assignee of the moiety takes a licence to use the patent and have an account only; and further, that even when the original patentee has assigned the other moiety, and that has become vested in the assignee of the first moiety, so as to make the two moieties then come together in the assignee, yet that the original franchise legally remains in the original patentee without any beneficial interest at all, but the right remains in him, and that the party in whom both the moieties are vested still remains an imperfect owner. Chief-Justice Erle thought, however, that if such a contention were established, it would be most inconvenient. His lordship considered that the act contemplates the assignment of a patent, and shares of a patent, and that an interest in the moiety of a patent would pass, and that the assignment of the second moiety to the same party would vest the whole of the patent in that party. Further, as to the rights of an assignee of part of a patent, it is now perfectly clear that he may sue alone for an infringement without joining in the action others having an interest in the patent, but no interest in the particular damages.

In the next place, we may consider what is the position of a licensee. The usual course is that the licensee receives permission to use the patent on payment of certain royalties to the licensor, and a main principle is that he cannot deny the validity of such patent. In a case connected with the manufacture of carpets a licensee had obtained from patentees a set of machines, and subsequently obtained another set of the same kind of machine from another quarter. The patentees claimed royalties on both sets, but the licensee set up a defence that the second set of machines were not identical with those of his licensors. The question of fact as to the identity of the machinery was decided adversely to the licensee, and thereupon, in addition to the principle settled as above stated, a question arose whether the obligation of the licensee not to dispute the right of his licensors extended also to the machines obtained by him from another quarter, which were constructed in violation of the patent right. The Lord Chancellor did not consider that there was any doubt that this should be answered in the affirmative. The fact, however, that a person has been licensee of a patent does not stop him from contesting the validity of the patent after the licence has expired.

It has been mentioned that any number of persons may be joint owners of a patent, and it is material to consider what the position of joint owners is. The subject was considered with reference to Green's patent for lawn mowers and garden rollers. The letters patent had been granted to three persons, and the Lord Chancellor (Cranworth) said, "Where such a grant had been made to two or more as joint inventors, it is dangerous for any court to allow one of the grantees to set up a title against the others founded on mere parol (verbal) evidence, or inference from doubtful conduct. The grantee who in such a case claims an exclusive right, ought to obtain written evidence on the subject; and if, by omitting to take such precaution, he is put to a loss, he has himself only to blame." "The right conferred," he said, "is a right to exclude all the world other than the grantees from using the invention. But there is no exclusion in the letters patent of any one of the patentees. . . . There is no principle in the absence of a contract which can prevent any person, not prohibited by statute, from using any invention whatever. Is there then any implied contract, where two or more persons jointly obtain letters patent, that no one of them shall use the invention without the consent of the others; or, if he does, that he shall use it for their joint benefit? I can discover no principle for such a doctrine. It would enable one of two patentees either to prevent the use of the invention altogether, or else to compel the other patentee to risk his skill and capital in the use of the invention on the terms of his being accountable for half the profits if profit should be made, without being able to call on his co-patentee for contribution if there should be a loss. This would be to place the parties in a relation to each other which I think no court can assume to have been intended in the absence of an express contract to that effect." Therefore, the principle as to joint owners of a patent is that each should be free to make use of the invention under the letters patent.

In a case which arose in 1869, one of two joint owners assigned his share in a patent, and released the assignee from all actions and suits by himself and his partner. The assignment was entered on the register of proprietors, but Lord Romilly ordered the whole deed to be expunged. Where A and B are patentees, he said, both may use the patent, but B cannot dispose of A's share.

We next proceed to consider the position of a purchaser of a patent. A very nice point arose in a recent cause in the Court of Queen's Bench as to the right of a purchaser to refuse to complete his purchase of a patent, on the ground that the alleged invention was no invention at all. The position of the parties in such a transaction is explained by the Lord Chief-Justice Cockburn. "I quite agree," he said, "that where a man supposes himself to have invented something which may have been the subject of a patent, and another man under the same belief, and himself a seller, buys that invention, such a contract may well be, and the buyer takes his chance of its being a patented invention; and if it turns out that the invention does not prove to be new, then it won't do for the buyer to turn round and say, 'I won't buy, because it is no invention at all.' This is very different from the case of a man selling as an invention to another that which in point of fact existed only in his imagination, and had no result. I cannot help saying that in such a case the maker of such an agreement would not be bound by his bargain. There must be some industry used, some novelty produced, and then the man who buys it must take it such as it is." Then he goes on to notice another condition of things. "I can distinguish the case supposed from the case of an invention which has some foundation and effect, but which does not achieve the whole effect for which it was devised. In the case where there is some invention, but its efficacy is only partial, a contract may take place, and the persons contracting will be bound by their contract."

In an earlier case than that from which we have quoted, it was laid down that in the sale of an invention there is no implied warrant. The statement of the complainant, known to lawyers as the "declaration," set out an agreement which recited that the plaintiff had invented a method for the prevention of boiler explosions, and had obtained a patent for the use of the same in the United Kingdom, and was desirous of taking

out patents in foreign countries, and that the plaintiff "agreed to make over and transfer, and did thereby accordingly make over and transfer, to the defendants one-half of the said foreign patents when the same should be obtained, and one-half of the English patent." The defendant pleaded that the invention was wholly worthless and of no public utility, and was not new as to the public use thereof in England, and that the plaintiff was not the first and true inventor thereof. This plea, the court decided, was no answer to the action, on the ground that in the absence of any allegation of fraud it must be assumed that the plaintiff was an inventor, and there was no warranty, express or implied, either that he was the true and first inventor within the meaning of the statute of James, or that the invention was useful or new, but that the contract was for the sale of the patent such as it was, each party having equal means of ascertaining its value, and each acting on his own judgment.

Of course it is a different matter if there is a want of *bona fides* on the part of the person selling a patent or a right to use it. There is a decided case in which the plaintiff contracted that the defendant should have the exclusive right to sell certain things for which patents had been obtained. The plea there raised the objection that the plaintiff knew at the time of making the contract that the patent was void. The patent being void, no right could be conferred under it, and therefore the defendant had no consideration for the promise to pay which he was alleged to have entered into.

On the subject of contracts by purchasers and licensees under patents, it must be taken, therefore, that unless there be fraud or a knowledge on the part of the vendor or licensor that the patent is void, or as a matter of fact the supposed patent does not exist, and no right is conferred, any contract entered into to make certain payments, whether as purchase-money or royalties, will be binding.

We have been dealing with the assignments of patents, and it is necessary shortly to notice that it has been suggested that an assignment of the right before the patent is taken out, enables the assignee to take out the patent. Some doubt, however, hangs about this point, inasmuch as the declaration required by the statute states that the petitioner is the true and first inventor, which would be untrue of a mere assignee. There is no doubt that the courts would be jealous of any abuse of the process provided by the patent law. One instance of such abuse is before us, where a party to whom a discovery had been communicated took out a patent in his own name, though a condition of the communication was that he should not avail himself or take any undue advantage of it.

Inasmuch as a licensee can have no interest beyond the term specified in his licence, he cannot apply for a prolongation of the term for which the letters patent were granted. It is otherwise as concerns assignees, to whom the Judicial Committee of the Privy Council will grant a prolongation, taking care, where there are assignees of a moiety only, and the patentee dies during the application, as occurred in the case of Herbert's patent for mooring buoys and light vessels, to secure the interests of his representative in the other moiety.

In concluding this notice of the rights and privileges of the patentee, we must remark that we have in this paper been dealing with his power to use his letters patent for the purpose of profiting by his invention, and we need hardly say that the payment of royalties on the granting of licences is frequently the largest source of revenue to an inventor, and the only source, short of assignment, where he is not his own manufacturer. But there is a very wide field in which patentees too often find themselves fighting for the protection of their rights, and this leads us up to the question of infringement. The letters patent, as we have already described them, speak of the *exclusive right* to use the invention which is granted to the patentee; and if any one interferes with this right, the patentee may proceed against him either at law or in equity. It may be premised that there can be no such thing as an infringement until the patent is taken out, or until provisional protection has been obtained under the provisions of the Patent Law Amendment Act, 1852. Such interference with the rights of a patentee may be restrained by injunction issuing from the Court of Chancery, and damages are recoverable against the person infringing. This is a part of the subject which will require to be dealt with at some length in our next paper.

TECHNICAL DRAWING.—LXXXII.

DRAWING FOR CABINET-MAKERS.

FIG. 625 is a view of a pedestal writing-table, with drawer and cupboard, the spectator being situated on the right of the object.

In commencing this, draw the entire block as if the drawer were not open, and regardless of the recess. When this general form is believed to be correct, draw the perpendiculars for the inner sides of the pedestal cupboards, the space between these representing the recess. To give to this space the appearance of depth, a line must be drawn to the point of sight from the inner line of the left pedestal, which must be terminated by a horizontal line representing the bottom of the back of the recess; a perpendicular at the intersection of these two lines will give the junction of the side of the cupboard with the back of the recess.

The doors of the two cupboards having been drawn, sketch the exact position of the drawer *as if closed*, for it will at once be understood that the angles of this rectangle will be those which will guide the edges of the drawer.

Therefore, through the two upper angles and from the lower one on the left side draw lines which would converge to the point of sight, since the edges of the drawer are of course parallel to the sides of the table.

Draw a horizontal line joining the two lines proceeding from the two upper points, and this will give the upper plane of the drawer. Draw a perpendicular at each end, the length of which will be guided by the point at which the one on the right side intersects the third line of the drawer. From this point draw a horizontal, completing the front of the drawer, which, it is obvious, will be really larger than the original rectangle; for, since the drawer is supposed to be open, its front is of course nearer the eye than the front of the table, of which when closed it formed a part; and thus, if this study were worked by perspective, the front of the table would be said to be "within the picture," since it could not be in the foreground, because if the plane of the picture were placed in front of the object with the drawer open, the front of the drawer would touch it, whilst the table itself would be at a distance equal to that at which the drawer projects from it.

The edge of the drawer—that is, the thickness of the wood of which it is made—is now to be added, then the divisions. Those known to be parallel to the sides will converge to the point of sight, whilst the others will be parallel to the front.

The rest of the detail, the desk, etc., will not require any special remark. The light is supposed to come from a point in front of the object, and on the left side of it; and therefore the whole of the right side of both table, drawer, and desk are shaded, as is also the right side of the pedestal which forms one of the walls of the recess, whilst the distant wall of the recess is covered with a middle tint. The shadow cast by the drawer falls on the front of the cupboards and into the recess; it becomes broader on the back of the recess, since that surface is farther back. This will be understood from the drawing, as will also the shading, etc., of the minor parts.

A few touches may be added to indicate the grain of the wood, but care must be taken not to overdo this, since absolute or laboured imitation of the graining is unnecessary and out of place.

WOODS USED IN CABINET-MAKING.

The following account of the principal woods used in cabinet-making will be found useful and interesting. The paragraphs marked (*) are quoted by express permission from Messrs. Holtzapffel's excellent descriptive catalogue:—

* *Best Furniture.*—Mahogany, walnut, rosewood, oak, various kinds; maple, satin-wood, Amboyna, black ebony, cherry-tree, Coromandel, sandal-wood, sweet chestnut, sweet cedar, tulip-wood, zebra-wood, camphor-wood.

Common Furniture and Inside Works.—Beech, birch, cedar, cherry-tree, deal, pine.

Even Grain, proper for Carving.—Lime-tree, pear-tree, pine.

MAHOGANY.

Although the mahogany is a native of too warm a climate to allow of its cultivation as a timber-tree in this country, yet it is applied to so many uses, and is so well adapted for most of them, that it has become essentially a "furniture wood," and therefore an extended notice of it is absolutely necessary.

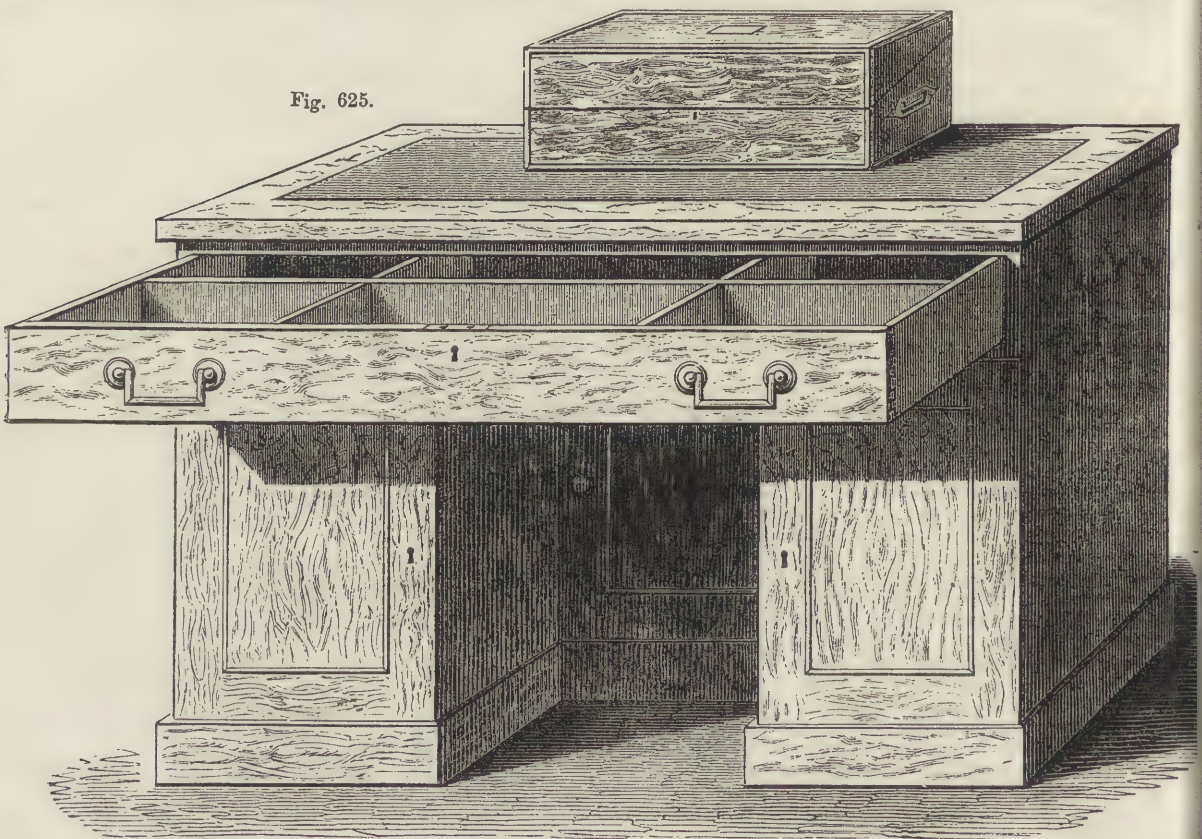
There are three species of mahogany: common mahogany (*Swietenia mahagoni*), *Swietenia febrifuga*, and *Swietenia chloroscylon*, the first being a native of the West India Islands and the central parts of America, and the second and third natives of the East Indies. They all grow to be trees of considerable magnitude, the first and second being among the largest trees known. They all afford excellent timber.

Swietenia mahagoni is perhaps the most majestic of trees, for though some rise to a greater height, this tree, like the oak and cedar, impresses the spectator with the strongest feelings of its firmness and duration. In the rich valleys among the mountains of Cuba, and those that open upon the Bay of Honduras, the mahogany expands to so giant-like a trunk, divides into so many massy arms, and throws the shade of its shining green leaves, spotted with tufts of pearly flowers, over so vast an extent of surface, that it is difficult to imagine a vegetable production combining in such a degree the qualities of elegance and strength, of beauty and sublimity. The precise period of its growth is not accurately known, but the time of its arriving at maturity is probably not less than two hundred years. Some idea of its size, and also of its commercial value, may be formed from the fact that a single log imported at Liverpool, weighing nearly seven tons, was in the first instance sold for £378, was resold for £525, and would, had the dealers been certain of its quality, have been worth £1,000. Mahogany of remarkable fineness is very costly.

As is the case with much other timber, the finest mahogany trees, both for size and quality, are not in the most accessible situations; and as it is always imported in large masses, the transportation of it for any distance overland is so difficult, that the very best trees, both on the islands and on the mainland—those that grow in the rich inland valleys—defy the means of removal possessed by the natives. Masses of from six to eight tons are not very easily moved in any country, and in a mountainous and rocky one, where little attention is paid to mechanical power, to move them is impossible, and thus much of the finest timber remains unemployed.

The discovery of mahogany was accidental, and its introduction into notice was slow. The first mention of it is that it was used in the repair of some of Sir Walter Raleigh's ships, at Trinidad, in 1597. Its finely-variegated tints were admired; but in that age the dream of El Dorado caused matters of more importance to be neglected. The first that was brought to England was about the beginning of last century, a few planks having been sent to Dr. Gibbons, of London, by a brother who was a West India captain. The doctor was erecting a house in King Street, Covent Garden, and gave the wood to the workmen, who rejected it as being too hard. The doctor's cabinet-maker was employed to make a candle-box of it, and as he was sawing up the plank he also complained of the hardness of the timber. But when the candle-box was finished it outshone in beauty all the doctor's other furniture, and became an object of curiosity and exhibition. The wood was then taken into favour. Dr. Gibbons had a bureau made of it, and the Duchess of Buckingham another. The despised mahogany now became a prominent article of luxury, and at the same time raised the fortunes of the cabinet-maker, by whom it had at first been so little regarded.

Fig. 625.



The mahogany-tree is found in great quantities on the low and woody lands, and even upon the rocks in the countries on the western shores of the Caribbean Sea, about Honduras and Campeachy. It is also abundant in the islands of Cuba and Hayti, and it used to be plentiful in Jamaica, where it was of excellent quality; but most of the larger trees have been cut down. It was formerly abundant in the Bahamas, where it grew on the rocks to a great height, and four feet in diameter. In the earliest periods it was much used by the Spaniards in ship-building. When first introduced by them it was very dark and hard, and without much of that beautiful variety of colour which now renders it superior to all other timber for cabinet work; but it was more durable, and took a higher polish with less labour. At that time it was called Madeira wood, though it appears to have come from Hayti and the Bahamas. Of course it was wholly unknown to the ancients. It was first introduced in the sixteenth century, but it was not generally used in England until the eighteenth.

MINING AND QUARRYING.—XXX.

BY GEORGE GLADSTONE, F.C.S.

SILVER (*continued*).

CUPELLATION—REFINING—GERMAN PROCESS—ASSAY OF BULLION—PROPERTIES OF SILVER—ALLOYS—PLATING—SALTS OF SILVER.

THE silver is separated from the enriched lead, or "lead riches" as it is often called, by cupellation. This interesting process has been briefly described in treating of the assay of silver ores, but the arrangements for carrying it on upon a large scale deserve further consideration.

This work is done in a reverberatory furnace of peculiar construction, the cupel forming the hearth, and being removable. Fig. 1 represents a horizontal section just above the cupel or test, and Fig. 2 a vertical one through the centre from side to side. The fire-place, A, is separated from the cupel, B, by a fire-bridge, C, and the waste gases, after having circulated over the surface of the metal, are carried off by the two flues, D D, which afterwards unite in a downward one, E, and pass through it to the chimney.

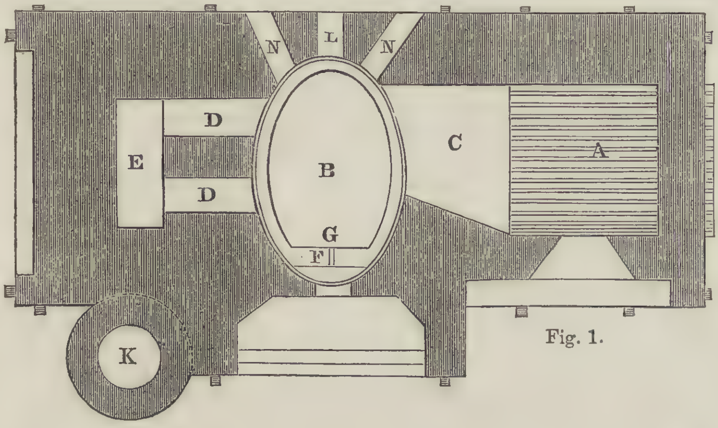


Fig. 1.

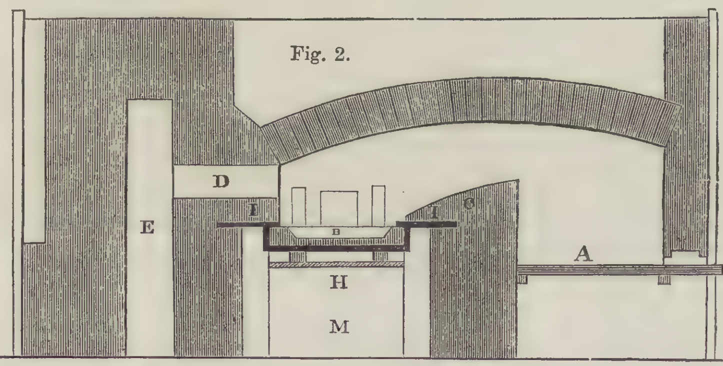


Fig. 2.

The cupel itself is contained in an oval iron ring about 6 inches in depth and 4 feet in its longest diameter; it is strengthened by having four broad straps of iron across the bottom, and riveted to the sides of the ring. To prepare it for use, ground bone-ash, together with $2\frac{1}{4}$ per cent. of pearl-ash, is worked up with just sufficient water to make it cohere properly; the iron frame is then filled with the composition, and it is beaten down into a solid mass. The centre part is then scooped out with a small trowel, until the bone-ash occupies the form indicated in the drawing, the sole being left $1\frac{1}{4}$ inch thick, and the sides sloping upwards; in front a portion, F, called the breast, is left of the full height, while in front of that again is a portion which is cleared out altogether: through the breast a little channel, G, called the gate, is made, for drawing off the overflow. A second and third gate is often made at the side of the first during the cupellation, as the original one becomes corroded and no longer serviceable. The cupel must be left for some days to dry before it can be used. When ready it is fixed firmly in its place, by being wedged tightly between the cross-bars, H, below, and the compass ring, I I, above.

The fire is only moderate at first, lest the cupel should crack and exfoliate by being too suddenly heated. When this is thoroughly annealed it is raised to redness, and then the lead riches which have been melted in a separate pot, K, are poured into the cupel. When the temperature of the furnace has risen to the melting-point of litharge, the blast, generally driven by a fan, is let on through the twyer-hole, L. The lead becomes oxidised by this means, and the litharge produced on the surface of the metal is blown forwards by the strength of the blast, and escaping by the gate G, falls through the open space in front into an iron pot, travelling on wheels, which is placed below at M to receive it. The cupel is always kept full; for which purpose pigs of the enriched lead are pushed forward through the pig-holes, N N, as required, which, as they melt, run in and mingle with the rest.

By continuing this process the richness of the alloy which remains upon the cupel will gradually rise; but when it reaches about 3,000 ounces to the ton it is desirable to draw it off, which is done by drilling a hole from below through the bone-ash, and letting the metal flow into another pot placed underneath to receive it. After being tapped the hole is closed up again with a plug of moistened bone-ash, and the operation proceeds as before. If the metal operated upon contained 250 ounces to the ton the tapping will occur about every twenty hours, during which time about 4 tons of lead will have been converted into litharge.

The very rich alloy which is produced by the first cupellation, is then refined a second time by a precisely similar process, and often in the very same furnace which was used on the first occasion. It is found best to make two separate operations of it, as the last part of the process needs careful management; and the litharge which passes off from the cupel will be richer in silver than the previous parcel. Just as the last traces of lead are being oxidised the fire should be urged considerably to remove them as completely as possible, and keep the silver thoroughly melted. After this the fire is withdrawn, and the silver is left to cool gradually. The cake of metal is then taken out of the cupel, any impurity is brushed off, and it may either be sold in that state, or remelted and cast into ingots. The moulds used for this purpose are made of iron, which are oiled and dusted over with charcoal powder before using. The silver thus obtained will only contain about 0·002 to 0·003 per cent. of lead.

The loss of lead during the two refinings will amount to about 5 per cent., but that which has been absorbed by the bone-ash of the cupel is recovered by being resmelted.

In some parts of Germany the whole process of separating silver from lead is done by cupellation; the first operation being performed in a furnace of peculiar construction, and the later ones in an ordinary bone-ash cupel. The former has a large hearth nearly circular in form, with an aperture on the one side for charging it, and another on the opposite side for the litharge to flow out. At the back is a furnace, and near it two twyer-holes for supplying the blast. The furnace communicates by a bridge with the hearth, and where wood is used it has no chimney. The hearth is covered by a sheet-iron hood, suspended to a crane, so that it can be raised and lowered as required. The hearth-bottom is made of brick, and this is overlaid afresh every time with a composition called "kalkmergel," instead of bone-ash. This particular kind of marl, which is found in some localities, contains a large proportion of carbonate of lime, there being about two-thirds of the latter to one-third of clay. Where a marl possessing the proper qualities does not already exist, it

is made by working two or more up together in such proportions as may be required. During the cupellation it becomes permeated with oxide of lead to the depth of 2 or 3 inches; this portion is separated from the rest, and returned to the lead reduction works. The hearth is usually about 10 feet in diameter, and in the Hartz district about 8 tons is the usual charge: the loss of lead during the operation amounts to about 8 per cent., and the "blicksilber" produced contains from 94 to 95 per cent. of fine silver. The blicksilber is again refined in a bone-ash cupel similar in principle to that used for the same purpose in England.

Bullion always contains more or less alloy; the English standard is 11 oz. 2 dwt. of fine silver to the pound, equal to $92\frac{1}{2}$ per cent. The value of it, therefore, can only be ascertained by having it properly assayed. The principle upon which this is conducted is precisely the same as that already described for the assay of silver-lead; but greater precautions are taken to ensure accuracy of result. A small piece of silver, usually about 10 to 15 grains, is cut off each ingot that has to be assayed; these are flattened out, carefully weighed, and wrapped up in pieces of sheet-lead. The requisite number of cupels is then placed in the muffle of the furnace; when heated, a sufficient quantity of lead is put into each, and as soon as that is melted the silver is put in. The furnace is regulated with great care, and when the whole of the lead has been absorbed by the bone-ash, the bead of silver remaining is taken out and weighed, and the result compared with that of a silver standard which has been simultaneously submitted to the same operation. A further allowance for the amount of silver in the lead used, will give the exact determination. The result is usually recorded as so many dwts. "better" or "worse" than the English standard, but the calculation is not carried below the half dwt.

Pure silver is a brilliant white metal with very high lustre, and possessing several valuable properties which would lead to a multitude of applications in the arts were it not for its great cost. It melts, according to Daniell, at 1,873° Fahrenheit, but there is always some uncertainty about the determination of high melting-points, and other experimenters vary slightly from him either on one side or the other. Its specific gravity, 10·5, is low as compared with the other noble metals; so that without being reduced to such an extreme thinness as gold is capable of, a given weight of silver can be made to cover a greater surface; one grain, indeed, can be beaten out into sheets the united area of which will amount to 98 square inches, a test of its malleability which makes it rank in this respect second only to gold.

Its tenacity renders it specially suitable for wire-drawing, one grain being capable of being drawn out into a wire 400 feet in length. But in the progress of both the operations of beating and drawing it becomes brittle, and has to be annealed from time to time. For both these purposes it is of the greatest importance that the silver should be as pure as possible, as the smallest admixture of alloy impairs its malleability and tenacity.

Of all the metals silver is the best conductor both of heat and electricity. It is therefore especially suitable for many experiments connected with the latter science; while, on the other hand, it renders necessary the breaking of the connection, by some good non-conductor of heat, in the handles of tea-pots and coffee-pots made of this metal.

Pure silver does not combine with the oxygen of the atmosphere at any ordinary temperature; but any alloy with copper will, on exposure at a red-heat to the action of the air, turn black on the surface in consequence of the oxidation of the copper contained in it. Sulphur, however, readily acts upon the pure metal, producing a dark-coloured stain, and hence it soon becomes tarnished in London or any other large town, the air of which is always more or less impregnated with sulphurous gases from the coal fires, gas lights, etc.

All the alloys of silver are harder than the metal itself, but few of them are of much utility except that with copper, as this metal does not materially affect its colour, even when the proportion of the latter is considerable. Thus the $7\frac{1}{2}$ per cent. of copper which is added to the pure metal to make standard silver, still leaves a compound of sufficient brilliance and whiteness; and for the purpose of the coinage such an addition is absolutely necessary, as the pure metal is too soft to bear the constant wear and tear of daily circulation. The two metals, however, do not perfectly combine, and the centre of the ingot produced is always found to contain a rather larger proportion than the outside: in minting it the metal is cast into bars of 18 inches long by 1 inch thick, and then rolled out into ribands of the thickness required for the coins which are intended to be struck. In Switzerland an alloy consisting of 90 per cent. of silver and 10 per cent. of nickel is used for coinage; and for various other useful purposes a larger proportion of the inferior metal may be used. A compound containing 13·4 per cent. of nickel is of a greyish-white colour, and takes a high polish, besides which it is highly magnetic.

Beyond the almost universal employment of silver for the purpose of a circulating medium, large quantities of this metal are used for ornamental purposes. The productions of the silversmith are principally the result of hammering, the operations which they have to undergo in this manufacture being very similar to those already described in our paper on "Copper" (Art. XXI.). The surface of the silver, after the vessel or other article has been duly shaped, will present a dull appearance and show the marks of the hammer: it has, therefore, to be burnished. If the vessel to be operated upon is hollow, as in the case of a coffee-pot, the inside is first filled with a composition of rosin and other ingredients, so that it may have the firmness of a solid, and not be injured in shape during the process. Such patterns or devices upon the surface as may be required for ornamentation are produced by chasing and engraving. The latter plan involves the cutting into the metal with a sharp-edged tool; the former kind of work is done by hammering the particular parts of the surface intended to be chased upon a steel block.

In making silver-plated goods very great improvements are due to the application of electricity. Upon the old system of plating described in the paper just referred to, the silver after a certain amount of wear was liable to peel off from the inferior metal; but electro-deposited silver is so intimately united to its foundation that the two metals cannot be separated. The process of electro-plating is a very simple one. A bath of silver solution is made by dissolving one pound of cyanide of silver in 100 of water in which ten pounds of the yellow ferrocyanide of potassium has been already dissolved. In this the copper vessels to be plated, after first being rendered perfectly clean by boiling in caustic potash, and then dipped in acid and washed, are suspended by wires. Connection having thus been made with the positive pole of the battery, the copper will become the negative electrode, and will cause the decomposition of the silver solution, and the deposit of the silver in the metallic state over the surface of the copper. One advantage of this process is that it is applicable to the most intricate pattern; and besides this the projecting points and angles of the objects plated, which will afterwards be subject to the greatest amount of wear, are just those which will receive the thickest deposit of silver by this voltaic action.

Some of the salts of silver have a variety of useful applications. The nitrate, familiarly known as lunar caustic, is of constant use in chemistry and in medicine; and, though colourless itself, possesses the property of turning to a dark colour on exposure to the light. Hence it is the essential ingredient of most of the indelible marking-inks; and has been extensively adopted by photographers. The chloride, iodide, and bromide are also similarly affected by sunlight, and are used for the same purpose.

Another combination of silver possesses properties of a very different character. By treating the oxide with strong ammonia, or a compound of caustic potash and ammonia, a product is obtained which is of a most destructive and dangerous nature. Fulminating silver, even when moist, will explode by percussion; but when perfectly dry the friction caused by the touch of a feather is sufficient for the purpose. It is analogous to the fulminate of mercury, and either preparation will serve the manufacturer of percussion-caps.

In jewellery, silver, though not used to the same extent as gold for this purpose, is frequently selected by the jeweller for the setting of stones which, though extremely beautiful in themselves, do not possess the same intrinsic value as the stones which are commonly known as precious stones. Among these may be mentioned the madrepore, agate and cairngorm. Chains, brooches, shirt-studs, wrist-buttons, and other similar articles, when made to resemble old silver by oxidation, are effective as ornaments for the person.

SANITARY ENGINEERING.—XXVI.

THE DRAINAGE OF VILLAGES AND COUNTRY TOWNS.

In the two papers immediately preceding the present, we have dealt with the detail of metropolitan drainage, giving as much information as the space at our command would allow, and we now take up the question of what may be called village drainage, as contrasted with large metropolitan centres: the conditions are altogether different, and another set of circumstances has to be considered. In large towns an ample water-supply, laid-on and available when required for flushing purposes, is supposed, at all events, to be at command, and the funds at the disposal of the authorities should be sufficient to provide the necessary engineering appliances in proportion to the requirements of the situation and the extent of the population; but when we fall below a certain standard, and have to deal with villages and hamlets, where perhaps the great majority of the inhabitants are poor, outlay becomes a matter of great importance, and the question of economy assumes a far more important aspect in its relation to efficiency than in larger operations; and here let us remark that the most perfect sanitary appliances are comparatively useless without what we may call personal attention. The most important, or one of the most important subjects upon which "education" is required, is that of making the best use of the appliances at command. Next to personal cleanliness nothing, perhaps, would be more conducive to the improvement of the general health of the community than a clear and intelligent understanding of the *rationale* of sanitary matters. The ultimate proof of the benefit of sanitary improvements is clearly and absolutely demonstrated by the actual decrease of the death-rate almost in exact proportion to the adoption of judicious measures in various localities, and in our next paper we shall go into this particular question at greater length, illustrating our position by well-authenticated quotations from Government authorities.

To return, however, to the immediate subject. In very small hamlets in poor districts, perhaps the best system of those alluded to in the course of our series is that of Moule's Earth Closets, described in our paper on this subject in Vol. III., page 341 of THE TECHNICAL EDUCATOR. Its efficiency and salubrity, when properly attended to, are undoubted, and the remanet of the soil is at once available for the garden or the field. No water-supply is required, and the fittings may be of the cheapest description; but personal care and attention are indispensably requisite, or else the evils attendant upon the most inefficient sanitary appliances are the inevitable result.

Advancing somewhat higher in the scale of population, we next come to towns which are small enough to be efficiently drained by pipe-drainage alone, but whose population and extent are not sufficient to require or to warrant the expenditure required for a system of brick-built sewers; and here we are indebted to a series of reports by J. W. Bazalgette, Esq., engineer to the Metropolitan Board, for some of our details. We must, however, first call attention to some points of general importance in connection with the subject. As a rule, pipe-sewers are not adapted to receive the surface drainage from those streets and roads upon which there is a considerable amount of traffic. If there be little or no traffic there will be proportionally little refuse dropped, and comparatively little detritus produced by wear and tear to be washed by rains into the sewers; and if the surface be paved, there will be less road-drift washed into the sewers than there would from macadamised roads. Pipe-sewers are not fitted to receive both house and subsoil drainage, for this reason, that their use in removing the house drainage either to the nearest streams or to a reservoir of deposit for disinfecting purposes, or otherwise, renders it a matter of necessity that their joints should be perfect, and that there should be the minimum of leakage; while the only means by which they can be made available for the latter purpose—viz., subsoil drainage—is by allowing the entrance of water throughout their entire course, by means of joints and other openings, which must manifestly neutralise their first and most important duty, by allowing the escape of the sewage through the surrounding ground. They should also be kept in a satisfactory state, have a considerable amount of water constantly passing through them, and they require, under almost all circumstances, comparatively steep falls, and to be very carefully laid. Where all these conditions can be complied with, the use of pipe-sewers only is undoubtedly advantageous. The size that should be used is the next question; and here let us clearly express our opinion that the most important point is to have them large enough, as a small pipe frequently gets stopped at a certain point, and as there is nothing above the surface to indicate it, the pressure of the water opens the adjoining joints, and the sewage passes into the surrounding soil, where, if circumstances allow of its easy escape, the defect may continue for many months before it is discovered. There may be many causes of obstruction—indeed, they are as various as possible. Extraneous substances causing gradual accumulation; external accident, the breaking of the pipe, the disturbance of adjoining ground for building or otherwise, the settlement consequent upon a new building, or even a trifling variation of the level of the pipe itself, may be mentioned as some of the most frequent. This, however, should always be borne in mind, that an error of level or a settlement amounting to three inches would entirely choke a pipe of that diameter, which, however, we consider, in the first place, too small for general adoption, although such have been used. It would half-fill a 6-inch pipe, and materially interfere with its efficiency, while in the case of a 12-inch pipe it would merely form a sort of bottom deposit of a quarter the depth of the pipe, and occupying a comparatively small section of its area.

We now abstract from Mr. Bazalgette's report some particulars of the drainage of the town of Rugby. The population is about 8,000, and there are about 1,100 houses. The house drainage was provided for by pipe-sewers, and water-works were carried out at the same time, the whole being finished in the year 1852. The public sewers are laid at an average depth of eight feet, and vary from six to twenty-two inches in diameter; the private sewers and drains, from four to six inches. The inclinations or falls are remarkably favourable, 1 in 50 or 1 in 60. The cost of the public sewers has been about £5,000. The water is laid on on the constant supply system, and the outlay for water-works has been £10,000; the water-pipes being laid about sixteen inches below the surface. The private works, in addition to the public sewers, cost about £8,800. The rateable value of the property included in the drainage area is about £28,000. A special rate of 10d. in the pound was levied to pay off the cost of public works, and for the supply of water 4d. in the pound is charged to all consumers, also 2s. 6d. per annum for each horse, and 1s. 6d. for every cow.

Sandgate is the next town to which the report refers. It is described as a remarkably healthy and pretty village, about a mile and a half west of Folkestone. It stands mainly upon a single line of road, parallel with and close to the seashore, at the foot of a range of hills, which rise precipitously from the sea, and prevent the extension of the line of houses except along the line of the shore. The beach, as well as the subsoil of the village, consists of shingle, the place containing, at the date of the report, 330 houses, and a population of about 1,400, considerably increased during the summer months by the visitors for sea-bathing, upon whom the population is mainly dependent for support. From its position resting upon a sea-beach shingle, it required comparatively little drainage, nature providing the most perfect subsoil drainage, as may be well imagined from the preceding description of the site.

The public sewers and water-supply were carried out under the General Board of Health, by their inspector, Mr. Rammell. No considerable extension of the village was contemplated or provided for in the general scheme. The sizes of the public sewers vary from six to twelve inches in diameter, and their inclinations from 1 in 6 to 1 in 320. The pipes are of stone ware with sockets, from London, and the joints are made with clay. The arrangement is peculiar, and would probably not be repeated at the present day; but as our object is not to start theories, but to give records of work actually carried out and in operation, we quote from the report:—

"The public sewers consist of four lengths of pipes, forming one line, under the north side of the main street. These lengths are severally of six inches diameter at the upper end, and increase to nine inches. They are arranged in two pairs, the lengths of each pair fall from opposite directions and meet at a certain point, from whence they discharge, through a common outlet at right angles with them, into the sea."

A reference to the peculiar situation of the place, described above, will render this description intelligible. These lengths measure 583, 320, 203, and 330 yards. The first portion of the outlet for the first two lengths is a 12-inch stoneware pipe, 73 yards in length; total, 1,509 yards stoneware pipe. The first two lengths discharge through a 12-inch pipe into a large egg-shaped brick reservoir, 7 feet 6 inches by 5 feet, and 60 feet long. The reservoir is below high water, and stores the sewage for about three hours per day. (For a detailed explanation of the *rationale* of this arrangement we must refer to some of our previous papers on this subject.) It is furnished with a flap and iron discharge-pipe to low water.

This describes the lowest section of the Sandgate sewage. We have before us the particulars of the other sections, but refrain from giving them, as they involve no practical detail or general principle which has not already been completely described in the course of these papers.

Now for the question of comparative outlay. In this we must include the water-works. There are two reservoirs: the western one 83 feet above Ordnance level, and the eastern one 67 feet. They are each capable of holding about 20,000 gallons, and the supply is derived from natural sources in the surrounding soil. The system is supposed to be that of constant supply. For details we must refer to previous papers; but when water runs short, as in the dry season, the water is turned off at night. About 25,000 gallons per diem pass through the sewers. The outlay may be taken as under:—

	£
Water-supply (about)	2,500
Public sewage	1,000
Private works and incidental expenses .	2,500
	£6,000

The rateable property in the drainage area is, say, £4,000; the water-rate is 1s. in the pound; the sewers' rate 6d. in the pound; and the general charges for supervision, etc., are paid out of the district rate, say 1s. in the pound; but this also includes a lighting rate of 6d. The report gives full detailed prices of the various items and materials used, but these our space compels us to omit.

The report next embodies some smaller particulars of Tottenham, but as they present no distinctive features, we omit them altogether.

One more example, and we conclude. We select the district of St. Thomas, Exeter. The population is about 6,000, and the total number of houses 678. The subsoil, to the depth of which the sewers are laid, is clean river gravel and shingle, showing that the lower portions of the district were at one time under water and subject to tidal influence. The public sewers were executed by Messrs. Dymond and Son, and consist of stoneware socket pipes of London manufacture, varying in diameter from four to eighteen inches, and in inclination from 1 in 22 to 1 in 1,000. The 18-inch and 15-inch pipes are almost entirely outside the town, and they are flushed frequently from places constructed for that purpose. The actual cost of the works, as quoted by Messrs. Dymond in a letter to Lord Palmerston, was £2,371. To this the private works have to be added, which may be assumed at such a sum as would raise the total outlay to £6,000. The rateable property and the sum raised annually for repayment of outlay, etc., we might quote; but having already given several examples of the working of the system, it is unnecessary to say anything more on this point.

Our object in this paper has been to show the practical working of the application of pipe-drainage, pure and simple, to villages and towns of limited population, giving a few financial data as to outlay and rates, and in every instance we have quoted the works have actually been carried out, and we are dealing with facts and not opinions. We should wish this paper to be read in connection with our previous papers on house drainage and the ventilation of house drains, as the one subject is in direct relation to the other, and had we space at command we might elaborate the application of our previous technical detail to the general arrangements described in the present article. We cannot, of course, attempt to give a history of the extensive sanitary works that have been in progress in various localities throughout the country within the last few years: our selection must be regarded as simply illustrative.

In our next paper we intend to give a few statistics as to the effect of sanitary improvements in diminishing the death-rate of the population, thereby reducing to a demonstrative certainty their advantageous effect; and the succeeding and last paper of the series will be devoted to a summary of previous articles, setting forth a comprehensive view of the general scheme upon which the series has been written, and enabling the reader in quest of special information to refer at once to that particular section of the subject in which he may happen to be most interested.

MAP AND PLAN DRAWING.—VI.

By C. C. King.

BOX SEXTANT—SKETCHING WITHOUT INSTRUMENTS—PLANE TABLE—CONVENTIONAL SIGNS—COLOURS USED—UTILISATION OF EXISTING MAPS—COPYING MAPS.

The "Box" Sextant.—Another equally portable instrument, and one of very great utility in rapid surveys, is the "pocket" or "box" sextant. The principle of its construction is identical with that of the larger instrument described in previous pages, that is to say, a movable arm, holding a mirror perpendicular to its surface, moves over a graduated arc, and reflects one of the two objects between which an angle has to be observed on to a fixed mirror or horizon-glass of which only the lower half is silvered. The main difference is, that the arc and arm are on the surface of a small cylindrical box, the cover of which can be screwed on to the bottom, and thus form a support for holding it in one hand. It is provided with a telescope, which is, however, rarely used except for adjustment, and reads by means of a vernier to one minute of an angular degree. Latitude can be determined by a meridian altitude, longitude by means of a lunar observation, and the heights of buildings or hills by observing angles of elevation and measuring a base, or a portion of it. Thus, if the point B (Fig. 20) be accessible, the angle B A C and the base A B being known, the formula $BC \div AB = \tan. A$ will give the height of B C.

Again, if it be required to ascertain the height of hill, C (Fig. 21), the angles B A C and B D C are observed, and these with the base, A D, will enable one to find, trigonometrically, the length of B C. The principal objection to the instrument is that the angles taken with it, in the triangulation for example, are not, as would be the case with the theodolite or compass, horizontal angles; but in rough surveying work this is of no material importance, and with a little care in measuring the angles to points vertically beneath the elevated ones, instead of those points themselves, very accurate results may be obtained.

The method of proceeding with the survey is the same as with either the theodolite or compass in its main features, only, as before remarked, the sets of angles are not taken with reference to a meridian, and hence the work is not so rapidly transferred to paper as in the case we have previously examined.

The plane table was an instrument formerly much used by surveyors for the completion of the details of a survey, the points of which had been already determined by other instruments; but as the principle involved is precisely similar to that we are about to describe, it will be unnecessary to make particular reference to it.

Sketching without Instruments.—It frequently happens that a sketch has to be made when no instruments are obtainable, but by means of a single sheet of paper, a pencil, and a straight-edged ruler or piece of wood, such as could always be procured, very valuable work can be produced. In sketching without instruments care is more than ever essential, and it must be always remembered that the principle on which surveying is based is invariably the same whether instruments are employed or not.

As before, therefore, the base is first determined on, and measured by pacing or otherwise; and the extremities indicated by pickets or sticks marked by attaching to them a piece of paper, or even a tuft of grass, so as to render them distinguishable at a distance. The observer then draws a line of any convenient length on his paper to represent the base according to the chosen scale, and placing the paper on the ground with one end of this line immediately over either extremity of the base he has measured, he moves the paper carefully until the base-line he has drawn exactly coincides with the direction of the measured base, the eye being kept as close to the paper as

Fig. 21.

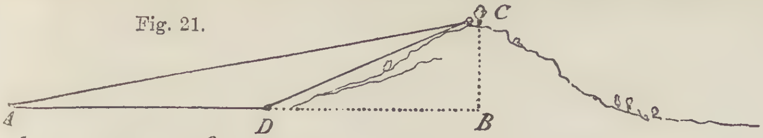


Fig. 22.

Fig. 23.

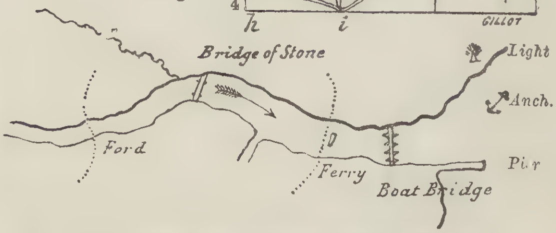
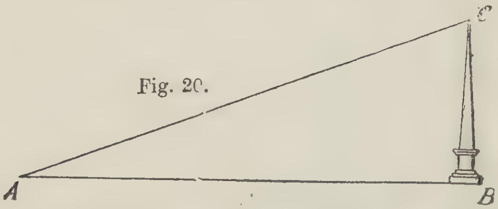


Fig. 24.—CONVENTIONAL SIGNS FOR RIVERS, ETC.

Fig. 20.



possible, and the straight edge of the ruler being used to guide the alignment. Without disturbing the paper, when so placed, he places the edge of the ruler close to the point representing the end of the base at which he is stationed, and aligns the edge again with a series of prominent features suitable for the points of the principal triangulation; and in each case, as soon as the edge of the ruler, while touching the end of the base, has its prolongation in the exact direction of the station observed, a

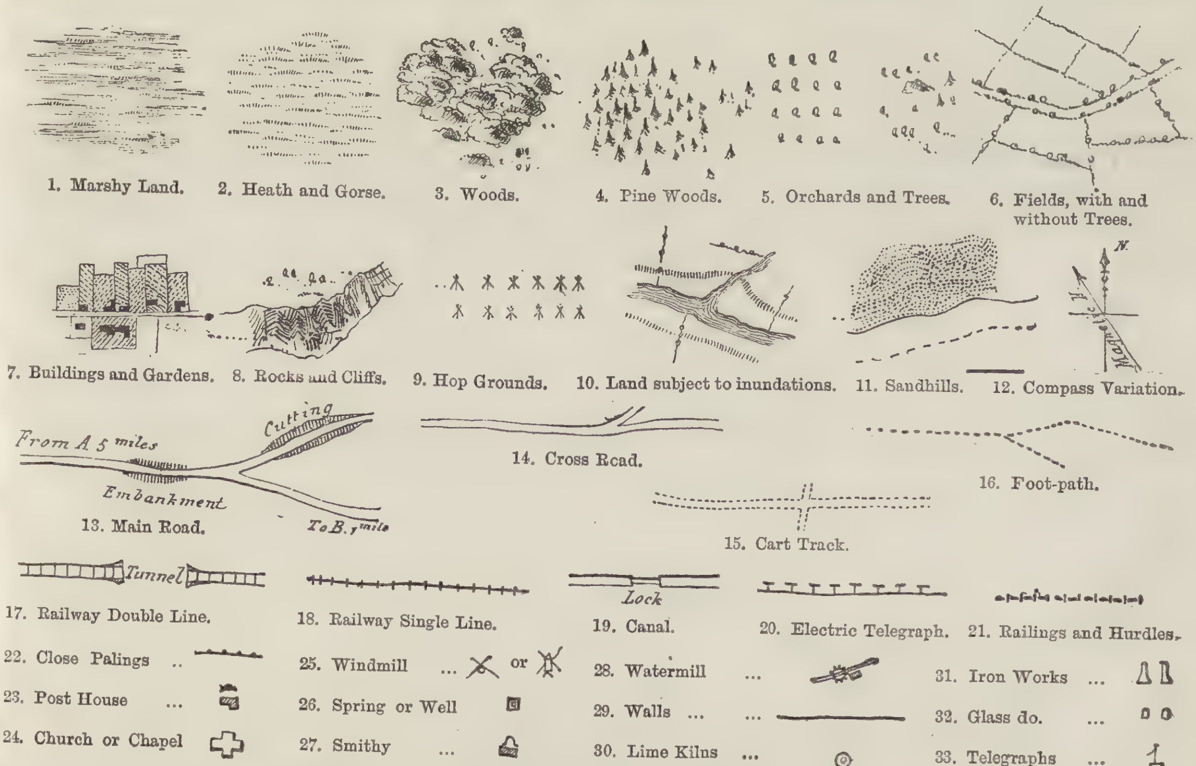


Fig 25.—CONVENTIONAL SIGNS USED IN MAP AND PLAN DRAWING.

line is drawn on the paper along the edge of the ruler, and thus the relative bearings of these different positions are transferred to paper. As in the previous case we have examined, the nature or names of the points whose bearings are decided by the lines should be noted down on them to prevent confusion.

Proceeding, then, to the other extremity of the base, the process is repeated, and thus, as before, the points of the triangulation are ascertained by the intersection of their respective bearings. Traversing is performed in the same way, that is, a known starting-point is chosen, and the paper fixed in its proper position by joining this point with any other one on the sketch, which is in reality visible from it, and, by means of the ruler, directing the line thus drawn on the point selected. The direction of the first straight portion of the traversed road can now be laid down by the ruler, and marked by the pencil on the paper. On reaching the place where a change of direction is to be made, the distance traversed is marked according to scale on the line previously drawn, and the point thus determined placed immediately over the spot where the last pace was taken, the line being then directed backward on the portion of road traversed. This again fixes the paper in a correct relative position, and a fresh bearing can be taken. Offsets are made in the usual manner, hill-tops, etc., sketched in, and slopes judged by the eye, and drawn according to the scale of shade. Much depends on the judgment and practical experience of the operator, as though it is possible he may have a clinometer, or may have even constructed one, it is more likely that he will, in such a case as would necessitate an immediate rapid survey, be unprovided with anything but the actually necessary materials of paper and pencil.

Plane Table.—The plan described is a practical adaptation of the principle of the plane table, the difference being that the latter instrument has a square table, that may be levelled by a spirit-level, supported on a tripod-stand, and furnished with a small compass at the side. A ruler is laid on it, and the bearings taken by the eye, though in some cases the ruler itself is provided with sights.

Conventional Signs.—For convenience' sake, and also to facilitate both rapidity of reading and uniformity of appearance in sketches, a series of conventional signs are used to delineate the details of the sketch. They should be drawn, as far as possible, according to scale, and to some extent they vary in different countries. Those used in English maps are shown in Figs. 24, 25, but any others may be used to suit peculiar characteristics of the terrain, as long as their meaning is noted in a column of reference.

When it is necessary to save time, or in fact in any sketch that is not required to be printed, colours may be advantageously employed to express many of the details of the plan; and in wooded districts the use of tints of various kinds not only makes the sketch more readily readable, but is less likely to confuse or obscure the other portions of the work. The colour should always be laid on lightly and evenly; and in the case of forests, their shape and extent should be accurately defined by the wash.

Colours used.—The following is the list most generally employed:—

Brick buildings	Lake.
Wooden ditto	Indian ink.
Roads (metalled)	Burnt Sienna.
Roads (unmetalled)	Uncoloured.
Cultivation	Naples yellow.
Wood-work (in section)	Gamboge or yellow ochre.
Hard-wood trees (oaks, etc.)	Sap green, or Prussian blue and gamboge.
Park-land or downs	A paler tint of the same.
Heather	Very light tint of purple (lake and indigo).
Pine trees	Sap green and indigo, or gamboge and indigo.
Railways	Brick-red or black.
Telegraphs	Bright yellow.
Water or rivers	Cobalt.

The degree of preservation, or rather the respective value of the metalled roads for transport purposes may be indicated by the strength of the tint of burnt sienna used: for example, a good turnpike road would be darker than an inferior country road, and it must be remembered that when the sketch is inked-in before the colouring is attempted, some time should elapse, in order to allow the ink to dry. Solid Indian ink is far preferable to that sold in the liquid state for drawing, when tints are to be used, as it is not so likely to "run."

Utilisation of existing Maps.—It may frequently happen that a map of the area already exists, but it may not be of recent date, or, though giving much correct information, it may not show the latest artificial alterations in the character of the surface. In such a case, provided only the map be accurate as far as the main physical features, etc., are concerned, very rapid and trustworthy work can be performed by using the existing map as a framework on which to place a more careful delineation of the details. A tracing of the map is made, and then transferred to paper; but only the principal points and the direction of the main roads would be shown, so as to avoid confusion. If the sextant be used it will be unnecessary to determine the position of the magnetic meridian, and commencing from any known point, or from a place whose position is determined by a traverse from a principal known feature, sets of angles will be taken with reference to lines joining the successive stations with the points already shown on the paper, and roads or hedges then traversed in the usual way.

If we have the prismatic compass, we have first to construct on our prepared paper the lines for the use of the protractor, as before described. Taking up a position at any convenient station, and drawing on the paper a line uniting this point with some other one visible from it, the compass is directed on this second point, and the angle read. If, then, from the line already drawn, this angle be set off with due regard to the position of the north point, which should be on the proper side of the line, the magnetic meridian will be shown by a line passing through the point, thus found by angular measurement, and the position of the observer. Thus, in Fig. 22, assume the first station to be D, whence the church-spire, *e*, is clearly visible. Join D *e*, and read off the magnetic bearing, *e* D F. Join D F, and produce it; and finally, draw at right angles to it a series of guiding lines for the use of the protractor. It is evident that we can now find our place readily by interpolation at any point, and as we have already copied the main features, the minor details, such as the character of the slopes, the hill-crests, or water-shed lines, can be put in with rapidity, and the work completed in the usual way.

Practically, this is the principle on which maps are read. In taking any map for examination the first thing to be ascertained are the compass bearings, which are either shown in some convenient corner, or else, as in the case of the English Ordnance Survey, the map itself is constructed on a sheet of paper the sides of which represent the cardinal points, the top being the north. In either case let us assume that the traveller wishes to find his place on the map. In the northern hemisphere the sun is always south of the observer, and hence, if he turns his back on the quarter of the heavens in which the sun happens to be, he will be facing in a northerly direction, and, holding the map in the usual way, the top will be approximately north, and the map in its true position.

The meaning of the different portions of the drawing will be understood by a knowledge of the conventional signs, the rivers shown by the black winding lines, and the roads by double lines, which in the case of main highways are stronger, and with one much darker than the other. Altitude will either be actually marked or may be ascertained by reference to the contour lines, which will be numbered or have their vertical intervals denoted. Finally, the nature of the country will be expressed by the fine parallel lines of horizontal hachuring, or by the fine radiating lines of the vertical style, the degree of slope being represented by the relative depth of the shade.

Practice alone can perfect one in readily finding one's place in a map, and the difficulty lies only in discovering the names of the adjacent remarkable points. It is convenient in starting from some known point, say a church or village, at the very commencement of the journey for example, to take the compass-bearing of the road which the surveyor purposes traversing, and then to lay off, as before described, the position of the north point. There will then be no difficulty in fixing one's place by interpolation, for finding by inquiry the names of the most striking features near the observer, with the top of the map from him and facing north, he can ascertain their bearings, and lay them off from the points observed, the intersection of the

lines giving his place. If no instruments are obtainable, it must be left more to his judgment, and he must endeavour to trace the road he has already come from his starting-point, and by calculating roughly his rate of progress, his place will be approximately found. If, then, some one or two remarkable features near be noticed, and a guess be made at their distance from him at that moment, he can, by means of the map, ascertain what points there are on it of a character similar to those he sees before him; and by placing the top of his map to the north, and then turning it till the actual feature, say a church-spire, and the point marked on the map of a similar nature, lie in the same direction, he will be able to fix his place by the intersection of the line of road he has already passed over, and that representing roughly the bearing of the feature.

Thus proceeding from A (Fig. 22) along the road A B for about 3 miles, the traveller has reached a hill, C, and wishes to find his place. Turning his back on the sun, and holding the map with the top from him, he measures off 8 miles by scale from the point A on the map along the road to *c*. A church is marked at *e* and *f*, and a landmark at *g*, the former being distant about 2 and 6 miles respectively. On examining the country, two spires lie to his right front and a landmark to his left. Arranging, therefore, his map until these lie approximately in the same relative direction right and left, the intersection of their imaginary bearings at *c* will give the traveller's place. This is merely a matter of practice, and a skilled eye can find the requisite information very readily.

Copying Maps.—Maps or plans may be copied in various ways, depending on the requirements of the case. Where great accuracy is necessary the distance may be actually measured by compass or scale, and transferred to the copy, the principal points of the triangulation being first marked, and then the roads and hill-features in the usual order of work. But if rapidity of copying is desired, a tracing may be made by means of the ordinary tracing paper, of all the details, and this transferred to the new sheet by the employment of "transfer" paper. This is simply thin paper coated with black-lead, which is transposed, the coloured side downwards, between the tracing and the plain paper, and the lines on the former being carefully followed by a pointed pencil or piece of wood, an exact copy is made, the lines of which are easily erased, and must hence be marked immediately by pen or pencil. A copy may always be made if the papers are both thin by placing them against the window or a pane of glass fitted in an inclined frame, which renders the operation of copying less laborious than against a vertical surface; but in both the above cases great care is necessary to prevent the paper moving, and errors may also frequently occur unless the eye be kept perpendicularly over the sheet. The papers should be securely fastened together by needles, or prevented from moving by weights imposed on them.

When the paper is so thick as not to be transparent, the copy may be made by placing the original over the fair sheet, and pricking through all the salient and remarkable points with a needle held vertically, the details being afterwards filled in by measurement or hand. This necessarily destroys the value of the original map to a very great extent, and is not advisable for very carefully finished drawings. A better plan is to divide the original map into a series of squares or rectangles of any convenient dimensions, but the smaller they are the greater will be the accuracy of detail. A similar series is drawn on the paper on which the copy is to be made, and any point on the map through which two intersecting lines pass is selected for a starting-point, and the same place marked for the beginning of the work in the copy. Thus, in Fig. 22, A and A′ are the points referred to; and to enable the draughtsman to find the portion he is copying at any moment readily, the vertical and horizontal lines in both plans are numbered.

In reducing maps the same method may be adopted, but in this case the size of the squares on the copy must be in the same proportion as the scale of reduction required. Thus, if it be required to reduce it to one-half, the square for the copy will have sides of half the length of the original; if a plan is required to be enlarged to twice its former scale, the square will be four times the size, and so on. The details are then finished-in by hand, or the distances where lines, roads, etc., cut the sides of the rectangles measured from the nearest right angle are either transferred immediately to the copy, or, if a reduction is to be made, the lengths are divided on a scale into one-half or twice the true dimensions, as the case may be. In Fig. 23 the plan is reduced one-half, and the distances *h i*, *i k*, *k l*, etc., are respectively one-half the length of H I, I K, K L, etc. The sector may be conveniently used for this reduction in the following manner. Open the instrument until the distance between 10 and 10 on the "line of lines" (marked L) is equal to the length of the dimensions taken off the original map; then the space measured by a pair of compasses between 5 and 5 on the same sectoral scale will give the required reduction to one-half of the first measurement.

Proportional compasses may be advantageously used for the same purpose. They consist of two bars with compass-points at each end, the centre of each bar being slotted to admit of the free movement when loosened of a small sliding-bar with a clamping-screw, which further serves as the point on which the arms move. The principle of the instrument is simply that of similar triangles, and by altering the position of the slide in the slot the arms may be so adjusted that the distance between the points at one extremity bears a certain proportion to the space between those at the other end. This proportion is ascertained by means of a scale marked on either side of the slot on the flat surface of the bar, and in adjusting the instrument the two legs are placed carefully covering one another, the screw unclamped, the fine lines marked on the slider adjusted with regard to some proportional mark on the scale, and the screw again clamped.

A more complicated instrument, and one requiring more care in manipulation, is the pantograph, but it is a question whether a really accurate copy can be made by it, though a reduction can be made with very great rapidity. It consists of four brass rulers, two of which are larger than the other pair, forming a rhombus with two adjacent sides produced. The angles of the figure are jointed so as to admit of free movement, and one of the shorter sides, as well as the adjacent longer one, are graduated and marked ½, ⅓, etc., and have each a sliding index which can be fixed by a clamping-screw, and which has, moreover, a hollow tube either for receiving a pencil or for the purpose of being fitted on a pin fixed in a heavy circular weight called the fulcrum. The angles and extremities of the rulers move freely on small castors, and in the long arm which is *not* graduated is placed a tracing-point with which the two clamping-screws on the other arms of the instrument are aligned.

Thus the pantograph has free movement in every direction about a fixed point, and in cases of reduction this is furnished by placing the weighted fulcrum in the socket of the clamping-screw of the long graduated arm. If now the original plan be placed under the tracing-point in the other long arm, and a pencil be placed in the socket of the clamping-screw attached to the short graduated arm, all movements made by the tracer over the map to be copied will be faithfully repeated by the pencil on a sheet of paper placed below it.

In all cases of copying or drawing maps extreme care is necessary in the mere use of the instruments. Errors multiply so rapidly, and are so difficult to trace, that too much attention cannot be paid to fixing the positions of the main points of the triangulation. An error of a pencil line at this portion of the work may produce a very marked deviation from the true measurement at some other point; and still more in copying maps are errors likely to increase. Facility in taking observations is merely a matter of practice, and it would be almost impossible to give directions that would enable a beginner to acquire the power of using instruments successfully. Skill is only to be gained by actual practice in the field.

FISH CULTURE.—XII.

By Greville Fennell.

NATURAL ENGLISH BEDS — RESTRICTIONS ON DREDGING — TILES AS COLLECTORS—PARCS AT ARCACHON—WEEDS — FASCINES AND WOOD COLLECTORS—SPAT—TERMS AND PRICES IN LONDON MARKETS.

The diminution in oyster production which has taken place in England is not so great as in France; still it has been very considerable. Great natural beds exist, or have existed, in the estuaries of the Thames, Medway, Blackwater, the rivers of Essex and Suffolk, in the Solent, in Langston and Chichester harbours, Milford, Tenby, and other places. The same causes as

exist in France may be assigned for the falling off of the supply. Besides the public beds before named, a very large number of oysters are obtained annually from private grounds in the Thames, the Blackwater, the rivers in Essex, and from the rivers in Suffolk, from the Isle of Wight, from Cornwall and elsewhere. These fisheries are held either by corporations, as at Colchester and Ipswich, or by private persons and companies, as lessees or otherwise. Such private oyster-beds are almost invariably well cultivated, very considerable trouble and expense being bestowed on them by the proprietors, whose efforts are mainly directed to keeping the bottom of the river free from slush and weeds, and destroying the enemies of the oyster—as the star-fish, the dog-whelk (*Purpura lapillus*), crabs, and rough whelk (*Murex erinaceus*), etc. The star-fish encloses the oyster in its grasp, and breaking off the edge of the shell, contrives to devour the fish, whilst the whelks bore through the shell, and, it is supposed, abstract some fluid portion of the oyster, leaving the more solid parts to be eaten by the crabs, which follow in the wake of the whelk.

Fig. 26.—MODE OF USING FURZE BUSHES AS COLLECTORS.

Many attempts have been made to increase the means of breeding and fattening oysters by artificial culture. Amongst these may be named Southend, in Essex, in the Roach, Hayling Island, on the Hampshire coast, Herne Bay, Brading, in the Isle of Wight, and the Reculvers and Lymington; but we are not aware how far the foregoing undertakings have been commercial successes. The ponds of Mr. George Tomline, at Nacton, on the Orwell, gave a spat in 1867 and 1869, but not in 1868. The Medina Oyster Fisheries Company at Cowes and Newtown—twenty-four acres in extent—have obtained a considerable amount of spat; but how far their breeding operations have answered their purpose we are not in a position to determine. Nearly all these ponds are similar, the chief differences being in size, and in the kind of collectors used, some consisting of tiles, others twigs, or fascines, slates, stones, and shells, attached by tar or cement to boards, the depth of water varying from two to ten feet. The falling-off in Jersey and the seas about the Channel Islands (400 vessels having declined to three or four) is directly attributed to over dredging. In Scotland, where the most important beds in the Forth and Lough Ryan belong to private persons, and a close season and regulations are observed, accounts appear most favourable; while on the contrary, when some equally important beds were discovered at Wigton Bay, no restrictions being imposed, the oysters were soon dredged out, and may be said to be almost extinct there.

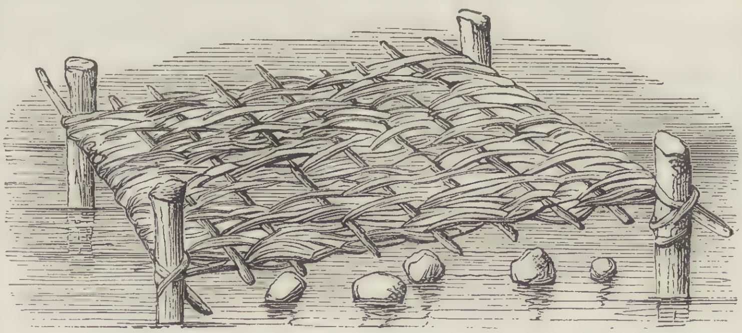


Fig. 27.—MODE OF USING WATTLED HURDLE AS COLLECTOR.

In Wales, at Milford Haven and Tenby, restrictions as to dredging and the size of oysters were once rigidly imposed, and all went well; but an increase of dredging has been permitted, and has greatly diminished the quantity on the beds. At Milford there were only 21 boats dredging twenty years ago: they frequently took 2,000 oysters in a day; now there are 200 boats, the take in the day does not exceed from 100 to 200. These instances go far to prove the wisdom of maintaining some regulations for the repression of indiscriminate dredging. At Arklow and Wexford, in Ireland, the beds have shown an annual improvement from a low state after over-dredging, the change being consequent upon the adoption of a close time, at the request of the fishermen themselves. Still cases are not absent even in Ireland, where positive injury had arisen from want of sufficient dredging, as in the estuary of the Shannon, near Scattery Island, and at Clew Bay, large accumulations of weeds and dirt having arisen. It is lamentable to read that out of 100 grants or licenses, comprising in the aggregate nearly 17,000 acres of some of the most desirable oyster-ground in Ireland, all have, as a whole, fallen very short of realising the expectations of those who promoted legislation on the subject. Hardly one of them has proved a commercial success, whilst most of them must be regarded as total failures, so far as the production of oysters—the greatest object of all—is concerned. In many cases the oysters laid down have fattened, and the grants have thus proved advantageous to the grantee; but this is a small object in comparison with the main object—increased production. The Commissioners attribute these failures almost entirely from not adopting adequate means to promote breeding, though there may be other causes yet to be discovered. The grantees, on the contrary, have satisfied themselves by reaping the benefit of the oysters already on the ground, and the fattening of those placed there. The Legislature never contemplated such a monopoly of the shore or sea-bottom for such purpose; and where the undertaking upon such exclusive privileges were given is not fulfilled, it should be withdrawn. Yet, "diminished as the supply of oysters is in Ireland, and suffering as this branch of fisheries is from exhaustion, there can be no doubt that the banks, both as regards stock and other conditions, are for the most part in a more satisfactory condition than those of the other portions of the kingdom, or of France." And this comparatively favourable state is unquestionably due to the salutary regulations framed and enforced by the Board of Works, whilst the fisheries were under that department, the observance of close time, and the efficient service rendered by the coast guard in carrying out these regulations.

From what has been written, it is not at all intended to prejudice the cultivation of oysters, when properly conducted. On the contrary, the cultivation of crassals (mud-lands) and ebb-dry foreshores is available for either associated bodies of fishermen or individuals. Indeed, it is especially adapted to the wants of a poor population, on a rocky coast, partly fishermen and partly farmers, such as we find in many parts of Ireland, and where the shores are suitable and the requisite materials abound on every side, only requiring labour to make them available. Oysters are not, as yet, so far destroyed at most of these places but they are obtainable by dredging; and if laid in the months of April and May would probably deposit a valuable spat in the parc cleared and prepared for them. From July to the following May no care or attention is necessary.

In the case, however, of estuaries of rivers, bays, harbours, or loughs, when the ground consists of mud-banks or weed-beds,

the process is somewhat different. There parcs may still be made, but it becomes necessary to attend more to the cleansing of the collectors. The collectors may be large flat stones or tiles; but tiles, as employed on the French plan, are easier to attend to, and easier to clean. The following illustrations will show the *modus operandi* :—

At Arcachon the parcs are made upon this plan, and answer admirably. A weed-bed is chosen, a considerable part of which is dry at low spring-tides. Upon this stacks of tiles, laid crosswise, one tier above another, until they reach some three or four feet in height, are erected and secured by stakes from injury by the run of the tide. About these the weed is hoed closely down, and the oysters are laid. When the spat rises, it drifts under the tiles, and the under side being almost always clear, more or less spat adheres to it. If the top side of the tile is sufficiently clean, much spat will adhere to that also. Hundreds of tiles may be seen completely crusted over with oysters, as many as two or three hundred being fixed on one tile, so that hardly a portion of the tile is visible. These stacks of tiles are erected about every twenty yards or so, the tops of the stacks being often protected by a thick planking, which is pitched on the under side, and is thickly strewn with shells of mussels, cockles, etc., which adhere to the pitch and receive a share of the spat. This covering aids to protect the young oyster from the effects of the sun during the two or three hours daily that they are exposed at low spring-tides. Fascines, or fagots or hurdles, are also used to arrest the spat, being pegged down in their places, and so secured from floating away; but these do not answer so well in open water as the tiles or stones. In foreshore cultivation shells are also scattered about near the oysters to receive a share of the spat; but these should not be cast down until immediately before the spatting season. One great cause why collectors do not answer at times is that they are often put down too long before the oysters begin to spat, and thus the tiles and shells, etc., become foul, the wood gets greasy or slimy, and the oysters will not adhere to it. Another reason for a defective spat often arises from the fact of the oysters being laid down too short a period before the spatting season. The removal of oysters from one ground and depth of water, just before the spatting season, to another, is often found to be prejudicial. The shorter time which elapses between the laying of the oysters and the spatting the better. Oysters laid on muddy ground often sink into the mud. So long as this happens gradually, the oyster does not suffer, for it contrives, by the flow of the water which it takes in and ejects, to keep a breathing-hole open; but when this occurs from a sudden storm, so that the oysters are buried without chance of securing an air-hole, they must perish. In France it is customary, where the ground is very soft, and the oysters sink, to raise them every two or three months, and replace them on the surface. In such cases, however, the oysters are usually put up for fattening, not for breeding, though oysters breed well enough either on mud-lands or weed-beds. When the oysters are only laid on weed-beds to grow or fatten, it is not customary to hoe the weed. The long, wet weed is found to be an admirable protection from the sun.

Fig. 28.—HURDLES OF BOUGHS USED AS COLLECTORS.

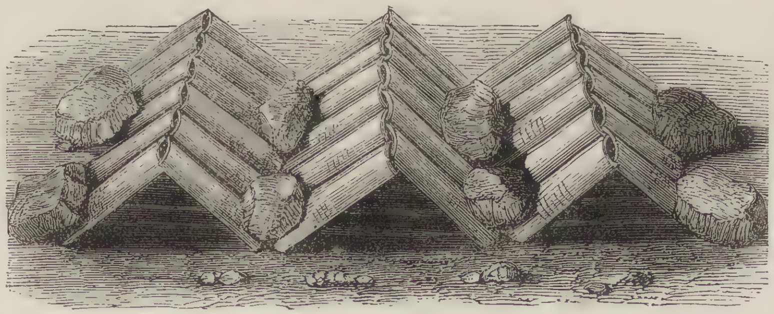


Fig. 29.—TILES PLACED ON A SLOPE AS COLLECTORS.

In Fig. 29 the tiles, it will be noticed, are placed on a slope: this is found advantageous in a strong current. When the tide runs for a long time in one direction, as in some rivers, and when the water is more or less muddy at times, the mud deposits on the back of the tiles, and the spat attaches on the other side.

Fig. 27 is more applicable where the flow is equal, and where as much mud is likely to be deposited by the ebb as the flood tide. The other methods given in Figs. 26 and 28 are employed indifferently in still waters, as in creeks, and also in open water, mud-banks, weed-beds, etc., in harbours.

The tank system of oyster culture in reality differs little from that already described, as far as the placing of collectors and oysters is concerned. The fault of many existing oyster-ponds is that they are too small in area, and not deep enough. The longer they are, within reasonable bounds, the better and more natural they will be for the oysters. From three or four acres to ten or twelve is the most useful and the most manageable size, while they should not be less than three feet deep, and should vary to the depth of ten or twelve feet. The water should have free access every tide, save during the spatting of the oysters, when no water should be allowed to escape, lest the spat escape with it. But in very hot seasons considerable evaporation takes place, more particularly in small ponds, and this causes a good deal of disturbance in the density of the water, which is prejudicial. This, therefore, should be carefully watched, and should it threaten to become dangerous it will be advisable to let in a portion of fresh water, if possible.

Weeds are often very troublesome in tanks or ponds, more particularly the green filmy weed *Cladophera*, known commonly as "blanket weed." This is very dangerous to the oysters, and means should be taken to remove it.

It is usual in ponds to gravel large portions of the bottom, in order that provision may be made to catch that portion of the spat which fails to adhere to the collectors; and the shortest time before spatting that this gravel is cast in the better for its

cleanliness. Hurdles and fascines, however, have been found to answer well in such places, and as a large number of collectors is required, they will be found much cheaper. They are fixed in rows by means of pegs, about two or three feet above the oysters, which are scattered on the soil under them, as shown in the illustration, though of course much more plentifully than they are therein depicted (Fig. 27). Furze-bushes (Fig. 26) are also found to answer fairly, and are cheap; but fascines and bushes are scarcely so suitable in a tideway, in consequence of the liability of the twigs to catch weed, break, and float away, when the spat is carried with them. In all cases when wood is employed for collectors, it should be dry, hard, and sapless, and cut at least in the preceding season.

Oysters are more easily detached from wood collectors; the loss by damage to the shell or fish in breaking them off is least upon fascines, as the twigs are easily taken up. It is greater on hurdles, greater still on tiles, and greatest of all on stones. The young oyster, though somewhat malformed at times on twigs, soon regains its shape when detached without damage.

The tank or enclosure method is more particularly adapted for companies or individuals resident in the neighbourhood or the locality where such basins naturally formed exist, or where the enclosure can be rendered complete at a moderate cost. It is not adapted for the poorer class of the peasantry, but still it affords constant employment to a considerable number of persons; and it may be remarked that both for this and the foreshore cultivation the labour of women and children is available, a great portion of the duties required being of a light description.

It has been suggested that as there are many places around our coasts—notably Tralee, Carlingford, Achill, Belmullet, and other localities in Ireland—where the rocks naturally collect each year a large number of oysters, tiles would prove very effective. If too expensive for the class of persons who pick up these oysters from the rocks, it would be worth while for some one to advance the cost, and receive it back in the following year, when the harvest of oysters would enable the peasants to repay the loan; or, failing this spirit of enterprise in the inhabitants, the peasants should be taught to break up the rocks and place them in rows, as already shown in Fig. 25 (page 97), so as to offer clean surfaces for the spat that rises from the bay.

The best arrangements of tiles in such places as Tralee and Bantry would probably be that shown in Fig. 29; but in places where the ground admits of stakes being driven, those shown in Figs. 26 and 28 are preferable. Collectors of wood are unsuitable for such places, catching passing weeds, and becoming slimy and foul, and therefore useless, for it is of the utmost importance that the collectors be clean.

The oyster spats or spawns annually, from the month of May to the month of September; being hermaphrodite, each individual oyster is supposed to produce spawn. The oyster begins to spawn in the third year of its growth, if not earlier. The number of germ or ova brought forth by a single mature oyster exceeds one million. Oyster-spawn, when first ejected, is, in the language of the dredgers, "floatsome," and requires some prominent object to which to attach itself, such as shells, stones, etc., which have received the name of "cultch," although cultch is more appropriately applied to old oyster-shells. When observed in its early stages adhering to the cultch, the spawn has the appearance of spots of tallow, in which the shell is seen rapidly to develop itself, and very soon to form a complete miniature oyster. In this state it is called "spat," 25,000 of which, as nearly as can be estimated, go to the bushel. Spat in the second year is denominated "brood," of which from 4,800 to 6,400 make a bushel. In the following year "brood" becomes "ware," from 1,800 to 2,400 to the bushel; and in the fourth year "oysters" from 1,200 to 1,400 to the bushel. The food of the oyster, with every show of reason, is supposed to consist of minute infusorial animals, with which sea-water abounds. When kept in an aquarium, the oyster is observed to lie with its shell slightly apart, and by means of the ciliary organs or fimbricated margin of its beard, to create a continuous current of water, which thus brings within its reach the nutritive particles of which it stands in need, as well as to pass excrementitious matter, like other molluscous animals.

In the London market oysters are divided into two great classes—"natives" and "commons." Native oysters are those fed in the waters of the Thames estuary and the creeks of its affluents, both of the Kent and Essex sides.

The superiority of the native oyster consists in the relatively large size of the fish compared with that of the shell, its remarkable succulence and delicate flavour, and its compact shape, as well as in the hardness and brilliancy of the shell. The price at which natives sell is accordingly very high in comparison with that of other kinds, and has year by year been getting higher and higher.

By the term "commons" are known all other oysters, which, however, are distinguished from each other by the names of the locality from which they are taken—such as Channel oysters, Jersey oysters, West Country oysters, etc.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XV.—MANAGEMENT.

"*Trustees*" *versus* "*Director*."—The government of the British Museum is at present vested by Act of Parliament in a body of fifty trustees, consisting principally of officers of state and nominees of certain families whose ancestors have presented valuable specimens or collections to some of the departments of the institution; but among these fifty trustees there are not more than two or three who take any interest in natural history, nor can these hold direct official intercourse with the general superintendent, or the keepers of the department connected with that branch of science, who have neither vote nor voice in the administration, for all communications have to be addressed to the trustees in official form, through the principal librarian, who makes no pretensions to the name of a naturalist, but in whom, nevertheless, the administration of the Natural History Department is practically vested. With such cumbrous machinery—a capital illustration, by the way, of Dickens's celebrated "How not to do it!"—it is not to be wondered at that the scientific staff has since 1848 been asking in vain for more space—space in any form—and yet the administrators of the British Museum are very jealous of their officers communicating their necessities or ideas to the outer world, otherwise than through them, officially! Well might Edward Forbes have been inspired to sing the un-official lay of "The Red Tape Worm," when he felt how active brains, that saw clearly what *ought* to be done for the onward march of science, were held in check by the stolid drivers of the government engine "Routine," who can only move "slowly but surely," or rather, surely but very slowly, when they take some twenty-five years to make one move in the right direction. In 1862 "the bill to enable the trustees of the British Museum to remove portions of their collections" provided for the present system of administration being transplanted along with the collections themselves; but while the reorganisation of the Natural History Museum is on the *tapis*, it would be well to get rid of the burden of the trustee system, and adopt the simple form of administration which has been found to work so well at the Royal Observatory, at Kew Gardens, and at the Museum of Practical Geology—viz., the appointment of a "Director," who should enjoy prompt and unfettered use and application of the Parliamentary annual grant, for which, together with the general efficiency of the establishment, he would be immediately responsible to one of Her Majesty's Ministers, preferably to a "Minister for Public Instruction," so that scientific authority alone should reign supreme. In so vast and varied a collection, it would be well that a board of management, comprising the keepers of departments in association with the directors should be established, so that the interests of zoology, botany, mineralogy, and geology should alike be fairly represented, to provide against any particular department being developed at the expense of another,* as would probably be the case if one person held despotic sway over any museum embracing all branches of natural history.†

* Opinion expressed by the authorities of the Jardin des Plantes, as quoted by M. Vernueil, before the Parliamentary committee on the British Museum.

† In his report for 1870, Professor Agassiz states that regular conferences have been held among all the officers of his Museum, in

If the present opportunity now offered for so desirable a change of administration is lost, and the old system prevails, then, at least, it should be provided that five out of the fifteen persons who constitute the standing committee of the trustees must be scientific men; further, that both superintendent and keepers should have a voice, if not a vote, on all matters relating to the Natural History Department; that the superintendent should be present at all sub-committees affecting such department, being its official representative, instead of the principal librarian, as under existing circumstances, and the keepers when any question arose that involved discussion.

The late Sir Roderick Murchison, one of the scientific trustees of the British Museum, was of opinion, that some such system, by which the sub-committees could avail themselves of the practical experience and assistance of the heads of the Natural History Departments, in preparing all matters they had to submit for the sanction of the composite or standing committee, would involve a great saving of valuable time.

Appointment of Officers.—Another matter that requires attention is the present method of appointing the officials under the competitive examination system of the Civil Service Commissioners, which has led to some unhappy nominations, and in one case great public scandal, by the notorious incompetence of the person appointed. Naturalists, like artists and poets, "are born, not made." It has been said that schoolmasters class their boys as of a "mathematical," "classical," or "good-for-nothing" turn of mind; but of late it has been discovered that the latter often proves to be the "observing turn," that the old system of schooling never developed into the imago condition of the species *Homo investigator naturæ*. It is curious to note how seldom the mineralogist or chemist, though dealing with the varied forms of crystals he collects or produces in his laboratory, is a good crystallographer. Though a sound observer of the tangible characters of inorganic bodies, the facts of chemical reactions or of physical phenomena, he hands over crystallographic determinations to the mathematician; while the latter (except in the case of the astronomer) seldom deals with the observation of natural objects, much less with anatomical or chemical manipulation, the mind of the naturalist and mathematician being differently constituted, and governed by opposite instincts. Of late years many clergymen have entered the field of practical science; but till very recently the classical minds of our old universities have steadfastly opposed the introduction of science into the college curriculum, often through the idea, the most mistaken of all notions, that science was opposed to religion, regarding it rather as one of the temptations of Satan than as testimony of an omniscient Creator, till forced to waver and then give way before the steady onslaught in the cause of truth led by Adam Sedgwick of Cambridge, and Buckland of Oxford.

Many a youth of a classical or mathematical turn of mind, just fresh from school, and after being crammed by the grinder's art, could satisfy the requirements of the Civil Service Examiners as to his fitness for a gentlemanly appointment under Professor Owen at the British Museum, and, with the friendly influence of one or more of the fifty trustees, might (as has occurred before), without any special fitness as a naturalist, get a berth for life; while it has been said by a friend of Edward Forbes, that had his appointment rested on a Civil Service Examination, he never would have been Professor of Natural History at the School of Mines or at the University of Edinburgh. Professor Agassiz raises his assistants from such students of his class as show capabilities for the work of the practical curator; and young men with such tastes soon make their mark nowadays, and attract the notice of those whose recommendation would receive attention at the hands of the director; and after a probationary term at the Museum, the appointment might fairly rest with him it most concerned to be surrounded by efficient naturalists. The same would apply if it rested with the board of management previously defined. Vacancies should be filled up from the subordinates who had proved the most eminent experts in the branches for which there were openings, and not according to official routine of seniority; maximum of efficiency in the staff being a thing desirable in a national museum.

which they have carefully discussed all questions which relate to the efficiency of the institution.

The Museum Staff.—It is generally acknowledged that the present natural history staff would be insufficient for the work of the new museum, and that there should be re-arrangement of the salaries and duties. Besides the following officers at the annexed salaries—Director-General, at £800, rising to £1,000 per annum; Keeper of Zoology, £600, rising to £800; Keepers of Botany, Mineralogy, Geology, and Elementary Collections, £500 each, rising to £700—there should be Assistant Keepers for Mammalia, Aves, Reptilia, Pisces, Mollusca with Molluscoida, Insecta with Myriapoda, Arachnida with Crustacea, Vermes with Echinodermata, Actinozoa with Hydrozoa, Sponges with Rhizopoda and Infusoria, Botany, Mineralogy, Geology, Elementary Collections, fourteen, at £300, rising to £500 each, with fees arising from their lectures or demonstrations; fourteen corresponding Class Assistants, whose duties would be to sort, make a preparatory diagnosis of new acquisitions, mount, label, catalogue, and arrange specimens after an assistant keeper's identification, and according to his directions and approval, to give out the specimens required by working naturalists, and to supervise the studies to which they were attached, so as to have the disposition of their special collections at their fingers' ends, as initiatory to the higher posts as vacancies occurred, at salaries commencing at £150, and rising to £250 each.

The aim of these student curators should be to devote their studies to such groups as the assistant keepers over them took least interest in, so that every section of the entire collection might meet with its due share of attention. Thus, if an assistant keeper was distinguished for his osteological or anatomical knowledge of a class, it would be well to give him an assistant who was efficient in the zoological or external characters, etc., of that class or group, or *vice versâ*; though it is probable, with the introduction of science-teaching in our schools, and advanced methods of instruction in our colleges, future generations of naturalists will acquire general rather than departmental knowledge—when the term "zoology" shall not mean something distinct from the anatomical, histological, osteological, physiological, and embryological characters of animals, but rather a philosophical blending of these with a knowledge of their external forms, habits, and distribution in time and space. At the present day we cannot point to any system of zoology in the English language that contains such combined information, or even manuals of such a nature on separate classes. Thus we have no such work on the Echinodermata or Annelidæ; and it is to be regretted such contributions as Reay Greene's Manuals on the Protozoa and Cœlenterata, and Woodward's on the Mollusca, have not been followed up by similar useful text-books, wherewith to fill the numerous gaps in English zoological literature. This fact bears rather hardly upon those students who have to undergo the very practical examinations in the important subject of zoology at the University of London.

Professor Agassiz, in his Report for 1870 on the State Museum of Massachusetts, states that "one of the characteristic features of the museum is that all its officers are expected to work seven hours a day for the good of the institution; *no outside work, even of a scientific character, being admitted during that time.* All the officers are now co-operating with me in that spirit. It is no doubt to this devotion to the institution on the part of so many able workers that the museum owes its unparalleled and rapid growth." Might not a hint be taken from this?

Beyond the scientific staff, about fourteen class attendants would be required to supervise the cleanliness of the cases, and conduct of the visitors to the public galleries, etc.; supplemented by men from the corps of sappers, whose services have proved so useful at the South Kensington, and the Exhibitions of 1851, 1862, and 1871, who could serve as a permanent guard, familiar with the plan and ways of the building in the event of fire, to which end one of the non-commissioned officers might be appointed to act as resident fireman, telegraphic communication being established between his rooms and the nearest fire brigade station.

The director would require the services of a secretary to keep the accounts of the departmental expenditure of the museum; a librarian to take general charge of the books, periodicals, maps, etc., throughout the museum; and a resident "guardian" to superintend the traffic, gate and door-keepers,

warming apparatus, etc., and take general charge of the museum day and night, though the fireman would be the acting guardian during the night.

INDIAN RUBBER.—II.

BY GEORGE GLADSTONE, F.C.S.

PHYSICAL PROPERTIES—SOLVENTS—DISTILLATION—CAOUTCHOUCINE—WATERPROOF DOUBLE TEXTURES—SINGLE TEXTURES—SUBSTITUTE FOR LEATHER.

Before proceeding to the details of the Indian rubber manufacture it will be desirable to consider more fully some of its chemical properties. We have spoken generally of its resistance to both acids and alkalis, as well as to water and alcohols, showing it to be a singularly insoluble compound.

The name commonly given to it in France, and which is sometimes used in this country in an English dress, "gum elastic," is therefore altogether inappropriate, as all gums are soluble in water. So misleading a term should by all means be discountenanced.

As to the effect of water, the surface of a piece of caoutchouc blanches somewhat by continued immersion; but whatever may be the cause to which this change in appearance is due, it is practically impervious to water. Mr. Hancock adopted the following plan for testing this point, in the year 1826:—He made a fustian bag with a lining of thin-cut sheet-rubber (such as he was then manufacturing for containing gas), filled it with water, and sealed it up hermetically. It was then weighed, and found to be 1 lb. 1 oz. 4 drams. From time to time it was reweighed, and the date and present weight noted. In the first year it had lost 2 drams; in nine years it was reduced to exactly 1 lb., having during that period lost just 20 drams. During the next nine years the loss was exactly at the same rate, the weight in 1844 being 14 oz. 12 drams. After that period the loss became very rapid, the weights being—

In October, 1849	13 ounces	4 drams.
„ February, 1851	7 „	8 „
„ May, 1854	3 „	14 „

and when it was cut open in 1856, the interior was found quite dry, and the weight of the bag was 3 oz. 12 drams. The test, of course, is not a strictly conclusive one, because it does not account for the proportionally great annual loss after the first eighteen years; but this earlier term of the experiment shows that for practical purposes it may be regarded as impermeable to water.

The alkalis, even when caustic, exercise no action whatever upon caoutchouc, though exposed to their influence during long periods.

The majority of acids, too, especially when cold, produce little or no action. Nitric acid will decompose it to some extent in any case, but when heated it acts with violence. Chromic acid, aided by heat, reduces it to a soft gelatinous mass. Concentrated sulphuric acid acts slightly in the cold, but decomposes it rapidly with evolution of sulphurous acid when heat is employed.

Sulphur itself exerts a remarkable influence, which will have to be described in detail when treating of the manufacture of vulcanised caoutchouc; and the alkaline sulphides produce an analogous result.

The metallic chlorides possess the singular property of rendering Indian rubber even less soluble than it is by nature, by retarding the action of the comparatively few substances which act upon it as solvents.

Alcohol has no effect whatever upon it, and ether will only dissolve it when rendered perfectly free from all admixture of the former by repeated washings: even then it only dissolves a small quantity, and that will be at once precipitated from the solution on the addition of the least quantity of spirit. An ethereal solution on drying will leave nothing but pure caoutchouc behind, the ether separating entirely from the other portion.

Though slowly permeable by gases, they exercise no effect upon it, nitrous oxide forming the only exception. This was first noticed when little transparent balloons, made of a very thin film of Indian rubber, were filled with gas. A balloon thus inflated with hydrogen, or carbonic acid gas, will ere long collapse, and the latter much more rapidly than the former. This led to calculations being made as to the rate of transmission of the various gases. The late Master of the Mint used a septum of Indian rubber in many of his dialytic experiments, and he determined the comparative rate of their transmission into a vacuum on the other side of the septum, the velocity of their passage being as follows:—

Nitrogen	1·000	Oxygen	2·556
Carbonic oxide	1·113	Hydrogen	5·500
Atmospheric air	1·149	Carbonic acid	13·585
Marsh gas	2·148		

His experiments also go to show that the rate is in simple proportion to the thickness of the septum at similar temperatures; but that the rate is considerably increased by an elevation of temperature, at least, within a moderate range. These little toy balloons are distended until the film of Indian rubber is only about one-thousandth part of an inch in thickness; so that for purposes of ordinary use the material may be regarded as perfectly impenetrable.

Indian rubber is therefore a most convenient substance for the experimental chemist. It furnishes him with corks which will be quite tight, and unaffected by most substances; a thin sheet will be readily converted into an air-tight covering for larger vessels; but tubing of assorted sizes is the most useful of all in enabling him, without a moment's delay, to unite different portions of his apparatus with flexible, and, at the same time, perfectly tight joints.

There are, however, certain substances in which rubber is readily soluble, and these are of very great importance, because upon them many branches of the manufacture are entirely dependent. Most of the liquid hydrocarbons possess this property, and especially one which is obtained by the destructive distillation of caoutchouc itself. Benzol is a good solvent; so is the common coal-tar naphtha. Bisulphide of carbon will dissolve about 1 part in 20. Chloroform dissolves it freely. Oil of turpentine, and some of the fatty oils, will also dissolve it readily; but as the latter are not of a drying nature, they do not suit the purpose of the manufacturer. The others which have been named deposit the rubber on drying unaffected in any of its important qualities.

Caoutchoucine, which has just been referred to, is made by distilling Indian rubber in an apparatus specially constructed for the purpose, according to the plan shown in the accompanying diagram. The retort, A (Fig. 3), is made of iron, and is built up in brickwork, with a fire-place below, so that the whole under-surface and part of the sides are exposed to the heat of the fire, before the gases pass on to the chimney, E. A pipe, B, leads from its upper part to the worm, which is placed in the condensing tub, C, the lower end of which is fitted with a stop-cock, D. The retort has a closely-fitting iron cover, F, which is raised and lowered when required by the pulley and chain to which it is suspended. In the cover is a perforation through which a thermometer is passed for the purpose of regulating the temperature. At the commencement of the operation the retort cover is raised; a convenient quantity of common rubber is taken and cut into small pieces, and thrown into the retort, either alone or with not more than one-half its weight of the crude distillate from a previous charge. The cover is then replaced, and the fire lighted. As the thermometer approaches 600° Fahrenheit a dark-coloured liquid comes over, is condensed in the worm, and is drawn off through the stop-cock into a receiver. This is the crude liquid hydrocarbon, to which the above name has been given. As soon as the thermometer is seen to rise again to 600° and upwards, the fire is withdrawn, as the rise in temperature shows that the operation is over. The crude liquid is rectified by distillation, which is repeated as often as desired; at each repetition it becomes more and more volatile and colourless. It can be brought to a specific gravity of 0·67.

The process of rectification reveals the fact that the crude article consists of a combination of different hydrocarbons, as one distils over much more readily than another; and they also possess very different specific gravities. Thus the product of 0·67 specific gravity boils at 90° Fahr., another of 0·69 boils at 104° Fahr., and another, to which the name *hevéene* has been given (from Hevea, one of the synonyms of the Siphonia), is of 0·92 specific gravity, and boils at 599° Fahr.

Caoutchoucine is not only an admirable solvent for the very substance from which it is made, but it will dissolve also all resins, even copal being soluble in it without the application of artificial heat. It mixes readily with oils, and renders cocoa-nut oil fluid at an ordinary temperature.

As the Indian rubber of commerce consisted of very small and irregular-shaped pieces—bottles and the like—the attention of the earliest experimenters was naturally drawn to the desirableness of finding a suitable solvent for it, as being apparently the only means of making these small pieces available in any large manufacture. The application of heat would not answer the purpose, for it melts at 398° Fahrenheit, and unfortunately it does not return to its original condition on cooling, but remains permanently in a semi-fluid and exceedingly sticky state. Coal-tar naphtha, having been found to dissolve it without altering its constitution, was used for making a solution which could be spread over the surface of cloth, and which on drying should leave a perfect film of Indian rubber adhering to it, so that the article should be absolutely impervious to water.

This was the origin of the waterproofing manufacture. It was found by experience, however, that the film deposited from the naphtha had the same sticky surface as the rubber itself when freshly made in the forests of Brazil, and that some considerable time is necessary to dry it sufficiently to get rid of this inconvenience. This would hardly suit the manufacturer on a large scale, as it would involve the erection of an immense range of drying-lofts; and the expedient was therefore adopted of using two cloths, which, being waterproofed on the inner side, became as one substance by the adhesion of the caoutchouc, thus at once avoiding a sticky surface, making an extra strong article of wear, and protecting the film of rubber from the possibility of external injury. For a number of years goods made upon this principle were very largely used by those whose engagements caused them to be much exposed to the weather, though they were heavy and uncomfortable as compared with the manufactures of more recent days, and had a persistent disagreeable smell. This last objection was soon mitigated by the use of a mixture of equal parts of naphtha and the purest oil of turpentine as the solvent; and afterwards still further by using masticated rubber instead of the commercial article, as the former is much more easily dissolved than the crude substance is. The mastication process will have to be described in detail when we come to treat of the manufactures of Indian rubber without the aid of solvents.

The apparatus used in making the above-named class of waterproof goods consists of a vessel in which the solution is prepared, the machinery for spreading it over the surface, rollers for uniting the double fabrics, and a drying shed. A cylindrical vessel 4 feet deep, and the same in diameter, will contain 13 cwt. of caoutchouc, and a sufficient quantity of the solvent, the proportion of the latter being of course dependent on the thickness of solution that may be desired. The caoutchouc is cut into small pieces, and the whole is kept agitated by a revolving stirrer driven by machinery at the rate of sixty revolutions per minute. In the course of three days the article is ready for use. The cloth to be waterproofed is wound on a roller at one end of the gallery, and as it is drawn off from this it is smeared over with a quantity of the mixture, immediately after which it passes between a roller and a horizontal bar adjusted so that there shall only be just enough room for the fabric to pass through; thus the proofing is spread evenly over the surface, and in the case of a single fabric it only needs to remain exposed until dry; two or three coats of the proofing are, however, frequently given to the article, which must be dried between each. Double goods are made by bringing the two coated surfaces into contact, and passing them immediately between a pair of rollers, when they at once unite perfectly: the chief precaution necessary in this operation is to ensure that the two pieces are evenly stretched, or they will not lie smoothly afterwards, and that no creases are made in the rolling, as they cannot be taken out again.

Goods prepared upon the above principle are used for making air or water-tight articles, such as elastic cushions, beds, life-buoys, etc. etc., but as an article of dress they have very greatly gone out of date, a single texture, proofed on one side, being substituted as a much lighter and more agreeable article. When waterproofing was first introduced the stickiness of the surface could never be entirely cured, as the rubber, even after drying, would always retain a certain amount of the solvent. This difficulty has since been obviated by mixing with the solution of rubber a quantity of asphalte and plumbago; or silicate of magnesia with fuller's-earth, whiting, or ochres: the former combination will make a black varnish, and the latter a light one, the tint of which can be varied at discretion by altering the relative proportion of the ingredients. These are spread upon the cloth in the manner already described, and produce a good, glossy, and dry surface.

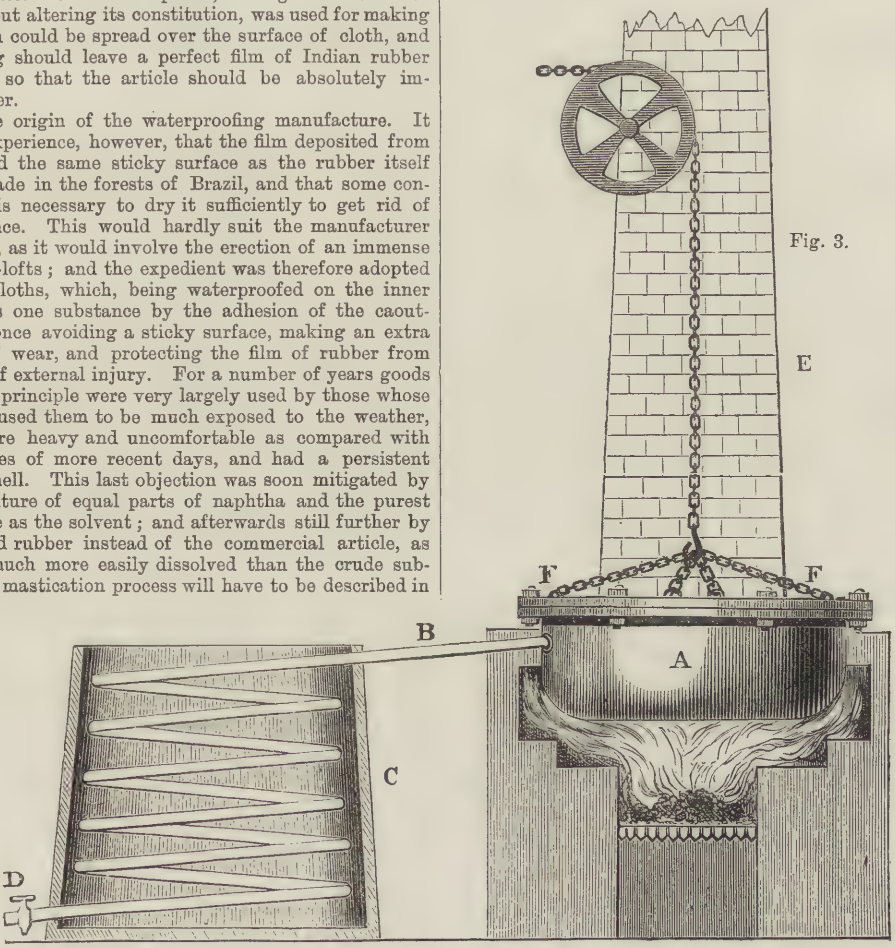


Fig. 3.

Various other modes have been devised of using solutions of Indian rubber. It has been employed as a substitute for leather in the manufacture of endless bands for driving machinery, and other articles in which flexibility is of importance. By taking any animal or vegetable fibres, which can be carded or felted, a

strap or sheet of almost any extent can be produced, and this serves as a medium for holding a composition of which caoutchouc is the important ingredient. It is reduced to a liquid by means of the usual solvents, and to this is added strong glue size, resin, ochre, and whiting, in proportions varying according to circumstances. The sheet or band is then saturated with this composition, pressed between boards or rollers, and dried. This operation is repeated until the fibrous foundation is completely permeated and covered by the composition. The article thus prepared has the advantage over leather for many purposes, as any amount of pliancy that may be desired can be ensured by altering the relative proportions of the ingredients; and the elasticity of it can in like manner be regulated by varying the manner of disposition of the fibres.

CAPITAL AND LABOUR.—VII.

By J. E. Thorold Rogers, M.A.

ARBITRATION.

There is, and, as long as their present relations subsist, there will be, a constant difference between the employer and the labourer. Each naturally strives to get as much as he can of the product which both are engaged in preparing for the market. It is quite as natural that the employer should look with great uneasiness and concern on the demands of the workmen for increased remuneration, though the effect of this demand, should it be successful, varies greatly with the nature of the occupation. The variation is caused by the extent to which the article produced is liable to a competition on the part of those producers, who either cannot or will not adopt any of those expedients by which the labourer is enabled to extort better terms from those who employ him. In order to understand this fact, it will be necessary to give certain illustrations.

If competition on the part of those who are engaged in the same labour is impossible, the cost, in case the rise in the rate of wages is not accompanied by an increased efficiency in labour, will fall on the general public, which, as I have said, is the real employer of labour. For instance, if the same wages are paid for fifty-one hours a week in the building trades, and the worth of the work done in the week is not equal to that which was formerly done in sixty hours, the person who will suffer will be the occupier of houses. There is no means, beyond perhaps the importation of joiners' work, by which a foreign or distant producer can compete against the workman on the spot. Assuming that the employer's profit is the same as that of persons engaged in other business, because it requires the same skill in superintendence which is given to other kinds of industry, the employer's profit will not fall. He will reimburse himself for the increased cost of the labour which he hires, by charging his customer a higher price for that which he sells him. The only way in which he can suffer is by diminished business, by a falling off in the number of orders which he receives from his customers. And it may be observed that, as the proportion which the cost of the necessaries of life bears to the income of the man who spends his means for them is always higher when the income is scanty, and as a house is one of these necessaries, any enhancement in the cost of lodging, due to the increased cost of building, falls most heavily on the poorest classes, partly because the price is heightened directly, partly because it is raised indirectly, since there is greater competition for the lowest priced houses.

Again, the object produced may be one which is open to free competition from countries where labour is less costly. Take for example cotton yarns. Now it is quite true that the product of every country is naturally protected by the cost of carriage against the product of any other country, as well as by other causes, which need not be referred to here. But this cost may be, as in the case to which I have referred, very small. If, therefore, British labour were more costly, or to use another expression, less efficient than, say, French labour, it might be the case that British yarns would be in unfavourable competition with French yarns, and thereupon both employer and workman might seriously suffer. This has not yet been the case, for workmen are fully alive to this risk, and apart from the fact that they do not make a demand which is suicidal, labour-saving expedients are constantly lessening the risk. Still it is a risk, and is certainly felt to be a hindrance to those who attempt to obtain better terms for their labour by means of trade combinations. Hence, one of the latest schemes by which the advocates of increased rates of workmen's wages have striven to meet this risk, is that of making trade-unions international, so as to attempt simultaneous action in different countries.

If, in the third place, the object on which labour is engaged is one which can be freely imported from abroad, and is a product of the soil, any increase in the cost of the workman's labour would fall on those who receive rent. In all agricultural operations, when the farmer's profit and the labourers' wages are paid, the residue of the price of agricultural produce goes to the owner of the land in the shape of rent. If the cost of obtaining this produce is lessened, the rent of land rises; and, by parity of reasoning, if the cost increases, the rent of land falls. This result could not indeed take place, if no such produce were imported from foreign countries. In such a case, the quantity produced tallying exactly with the number of persons who subsist on it, any enhanced cost in obtaining such produce would be put on the consumer. The same holds good with the produce of mines. The rise in the price of coal (1872), which has partly been for the good of the landowner, partly for that of the working collier, would be instantly arrested, and speedily reversed, if coal produced in foreign countries could come into the English markets, and compete against the produce of English mines. If, as has been predicted, English coal mines show symptoms of exhaustion, such a competition will ultimately occur. The same rule applies to mines of metals.

Now where, as is the case with two such articles as cotton yarn and iron, the market price of the product, determined in both cases by the demand for it, and in the former by the cost of the raw material, is fully known, it is exceedingly easy to arbitrate on disputes between workmen and employers; and such arbitration is constantly resorted to in this country, as a means of terminating other disputes. When prices rule high, the employer is able to give higher wages to those whom he hires; when, on the other hand, they are low, the workmen must, if they be wise and just, acquiesce in a reduction of their wages. These arbitrations have been established for some years past, and when the object is one in which two conditions are satisfied, that the price of the article at any given time is thoroughly well known, and it is subject in the fullest extent to foreign competition, there is no great difficulty in arriving at a calculation as to what should be the respective shares of the employer and the workman.

The case is, however, by no means so easy in the other two classes to which I have referred. In the first, there is no means by which the price of the article can be arrived at, and there is practically no competition among those who supply the article, apart from that which influences employers to seek for business. In the second, though the article is subject to foreign competition, it has been deemed improbable that labourers could state their demands with so much effect, as to enable the introduction of an arbitrator between themselves and their employers, though recent events seem to prove that such a combination may be successfully attempted. Undoubtedly there is one consideration in which labourers, employers, and the general public are equally interested. This is that there should be the greatest possible efficiency of labour, at the least possible cost of effort to those who are engaged in labour. Low wages, it cannot be too often said, are by no means the same as cheap labour. It can hardly be possible that with such rates of agricultural wages as are said to prevail in some southern English counties, the labourer can possess the heart and strength which are essential towards his being a good workman. If so, it is certain that a rise in the rate of such wages would be no loss to the employer, and a great boon to the labourer.

That some arbitration, settlement, or arrangement, which shall be based on the greatest possible efficiency of the labourer, should be aimed at, is plain from considerations which affect the general public. To this body every person belongs, or in other words, everybody consumes, and pays for, either in his own person or by those who do it on his behalf, those products of labour which he requires for his convenience or necessity. Now it is possible to conceive the extreme case of a general rise in the cost of wages, unaccompanied by any increased efficiency of labour. To make the case still more clear, let us imagine that this simultaneous rise were brought about by a personal action on the part of labourers, and that all shared in the process.

From the point of view which I have been taking in these papers —and which is, I think, incontestable—the employer, being paid wages for his work of management, would inevitably share in the rise which has been effected. Both employer and workmen thus get a higher remuneration in money than they did before the operation which they undertook. But money is not necessaries and conveniences; it is the means for procuring those articles which are the products of labour; the price, therefore, of any article would, in the case which I have stated, rise. The effect then would be that people would have, with great pains, and after a very hot and angry struggle, come round to exactly the same point from which they started, only finding this, that though they got more bits of gold and silver, the increased number would go no further in purchasing goods than the smaller number went to.

TECHNICAL DRAWING.—LXXXIII.

WOODS USED IN CABINET-MAKING.

MAHOGANY (*continued*).

The mahogany is a graceful tree, with many branches, which form a very handsome head. The leaflets are placed opposite to each other in pairs, mostly four, and sometimes three, but very rarely five, without any odd leaflet at the point; they are smooth and shining, lance-shaped, entire at the edges like those of the laurel, and bent back; each leaflet is about two inches and a half long, and the whole leaf is about eight inches. The flowers are small and whitish, and the seed-vessel has some resemblance to that of the Barbadoes cedar; hence some botanists have given the name of cedar to the tree.

It so far corresponds with the pine tribe, that the timber is best upon the coldest soils, and in the most exposed situations. When it grows upon moist soils and warm lands it is soft, coarse, spongy, and contains sap-wood, into which worms will often eat. That which is most accessible at Honduras is of this description: and therefore it is only used for coarser works, or for a ground on which to lay veneers of the choicer sorts. For the latter purpose it is well adapted, as it holds glue better than deal, and when properly seasoned is not so apt to warp or to be eaten by insects. When it grows in favourable situations where it has room to spread, it is of much better quality, and puts out large branches, the junctions of which with the stem furnish those beautifully curled pieces of which the choicest veneers are made. When among rocks, and much exposed, the size is inferior, and there is not so much breadth or variety of shading, but the timber is far superior, and the colour is more rich. The last description is also the strongest, and is therefore the best adapted for chairs, the legs of tables, and other purposes in which a moderate size has to bear a considerable strain.

Since the produce of Jamaica has been nearly exhausted there are only two kinds known in the market—bay-wood, or that which is obtained from the continent of America, and Spanish-wood, or the produce of the islands chiefly of Cuba and Hayti. Though the bay-wood is inferior to the other both in value and in price, it is often very beautiful, and may be obtained in logs as large as six feet square. It is, however, not nearly so compact as the other; the grain is apt to rise in polishing, and if it be not covered by a waterproof varnish it is very easily stained. It also *gives* to the tool in carving, and is not well adapted for ornaments. Spanish-wood cuts well, takes a fine polish, resists scratches, stains, and fractures much better, and is generally the only sort upon which much or delicate workmanship should be expended. The colours of mahogany do not come well out without the application of oil or varnish; and if the best sorts be often washed with water, or long macerated in it, they lose their beauty, and become a dingy brown. The red is deepened by alkaline applications, especially lime-water, but strong acids destroy the colour. When the surface is covered by a colourless varnish which displays the natural tints without altering any of them, good mahogany appears to the greatest advantage.

The *Febrifuga*, or East India mahogany, is a very large tree. It grows in the mountainous parts of central Hindostan, rises to a great height, with a straight trunk, which towards the upper part throws out many branches. The head is spreading, and the leaves have some resemblance to those of the American species. The wood is of a dull red colour, not so beautiful as common mahogany, but much harder, heavier, and more durable. The natives of India account it the most lasting timber that their country produces, and therefore they employ it in their sacred edifices, and upon every occasion where they wish to combine strength and durability.

The *Chlorolxylon* is chiefly found in the mountains of the Sircars, that run parallel to the Bay of Bengal, to the north-east of the mouth of the river Godovery. The tree does not attain the same size as either of the former, and the appearance of the wood is different. It is of a deep yellow, nearly the same colour as box, from which it does not differ much in durability; and it could be applied to the same purposes.

(*) "African mahogany (*Khaya Senegalensis*), from Gambia, is a more recent importation; it twists much more than either of the above, and is decidedly inferior to them in all respects except hardness. It is a good wood for mangles, curriers' tables, and other uses where a hard and cheap wood of great size is required. It admits of being turned equally as well as the others."

PINE.

(*) Pines and firs constitute a very numerous family of cone-bearing timber-trees that thrive the best in the cold countries. The woods differ in colour, partly from the greater or less quantity of resinous matter or turpentine contained in their pores, which gives rise to their popular distinctions, red, yellow, and white firs or deals, and the red, yellow, and white spruce, or pitch pines or larches.* They are further called by the countries or the ports from which they are shipped, as Norway, Baltic, Riga, Dantzic, and American timber, Swiss deal, etc.

WALNUT.

Before the introduction of mahogany, the walnut was the cabinet-makers' tree in England, and it was well adapted for the purpose, being tough and strong in proportion to its weight, beautifully variegated, admitting of a fine polish, durable, and obtained in sizes sufficiently large. In many parts of the Continent, where the expense of the carriage of mahogany is great, the walnut is still extensively used in the manufacture of furniture; and perhaps there is no native tree which bears the climate of England well that is better adapted for the purpose. Oak, though abundantly durable, cannot be finely polished without great expense, and it is heavier in proportion to its strength.

Within the last few years another change has taken place, and walnut furniture has again become popular. Fine old specimens of chairs, cabinets, tables, etc., that had been quietly resting in the lumber-rooms of large mansions, have been brought to light, repaired, and polished, and either reinstated in their former places, or sold at extremely high prices. The great demand for these antique specimens of furniture has naturally led to the resumption of the manufacture of similar articles; and hence we find that in drawing-room furniture especially walnut is now very extensively employed. One circumstance that has contributed to the renewed popularity of walnut is the revival of a taste for marquetry or inlaid work, for the lively and variegated colours of which this wood forms a very appropriate ground.

Of the walnut-tree (called by the Romans "Juglans," or the nut of Jove) there are very many species enumerated, which have been divided by modern botanists into three genera. Of these species it is necessary to mention only two as timber trees—the common walnut-tree (*Juglans regia*), and the white walnut, or hickory-tree (*Juglans alba*). The first of these is a native of the warmer parts of Europe, or perhaps of Asia, and the last is a native of America.

As is the case with all trees and plants that have been long known, esteemed, and cultivated by man, the original country of the walnut is not recorded. Some are of opinion that it is the "Persian nut" mentioned by Theophrastus, and that therefore Persia is the country from which it was first introduced into Europe. It is found indigenous in the more northern parts of that country, towards the mountains of Caucasus; sometimes, though more rarely, in the Russian territory on the north of those mountains; and in China. In all these situations it grows, according to the best authorities, in a state of nature, and propagates itself without cultivation. In the east of France, the south of Germany, and Switzerland, it is very abundant, more especially in Germany, in many parts of which,

such as the plains of the Bergstrasse, which run parallel to the Rhine, between the Neckar and Maine, there is hardly any other timber. In England there are still a good many trees scattered over the country; but the number is not so great as formerly, the partiality for the woods of the colonies and other foreign countries having diminished the value of this, as well as most other species of domestic timber used for finer purposes.

There is still, however, one use to which the walnut-tree is applied, in preference to any other timber, and this use demands the qualities of beauty, durability, and strength: walnut-wood is employed for the stocks of all manner of fire-arms. Before it is used, however, it should be well seasoned, or even baked, as when new it is very apt to shrink, a disadvantage which is completely got rid of by this process.

The walnut grows rapidly until it attains a considerable size, but the absolute duration of the tree has not been ascertained with accuracy: probably the most profitable age for cutting it is the average of hard-wood trees—about fifty or sixty years. There are several varieties of the common walnut, as the thick-shelled, which affords the best timber, and the thin-shelled, which has most fruit and yields most oil. The form which the branches of the walnut-tree assume is generally beautiful. In May the warm hue of its foliage makes a pleasing contrast with other trees, but it opens its leaves late, and drops them early.

The white walnut, or hickory, is a native of North America, where it grows to be a timber-tree of considerable dimensions. One part of the wood is more porous than that of the walnut, but the other is more compact. This gives the grain of the wood something the appearance of that of ash; and where it abounds it is used for similar purposes—the small shoots for hoops, and the grown trees for agricultural implements. Hickory is very tough and elastic, and therefore it answers remarkably well for fishing rods, the shafts and poles of carriages, and other purposes where a slender substance of timber has to resist sudden jerks or strains. In favourable situations, the hickory grows well in England; the specimens in the arboretum at Kew Gardens being of great size for their age, and very handsome trees. The trunk rises to a considerable height, of nearly uniform thickness, as straight as a line, and without any lateral branches.

PINUS SYLVESTRIS.

Lance-wood (*Guatteria virgata*) is a native of the island of Jamaica, and though it does not grow to a very great size, it is perhaps one of the most valuable timber-trees in the island. No timber possesses in a higher degree the quality of toughness and elasticity, therefore none can be better for the shafts of light carriages, and every other purpose where a small body and weight of timber is required to stand a great strain. The very best ash, the toughest of our native timber, is greatly inferior to lance-wood, both in strength and elasticity; and in consequence of ash being open and varied in the grain, while lance-wood is close and uniform, it does not carve so well into ornaments, take so smooth a polish, or admit of being varnished with so little labour.

The hassagay-tree (*Curtisia faginea*) is a larger growing tree than the lance-wood, being one of the largest timber-trees in Africa. Its leaves resemble those of the birch; the timber is compact, firm, and stiff. It is not so much used in this country as the former.

(*) "The royal or common walnut is a native of Persia and the north of China. Walnut was formerly much used in England before the introduction of mahogany. The heart-wood is of a greyish brown, with black-brown pores, and often much veined with darker shades of the same colour; the sap-wood is greyish white. Some of the handsome veneers are now used for furniture, but the principal consumption is for gun-stocks, the prices for which in the rough vary from a few pence to one and two guineas each, according to quality. An inferior kind of walnut is very much used in France for furniture, frames of machines, etc.; it is less brown than the fine sort.

"The black Virginian walnut is a native of America, and is found from Pennsylvania to Florida. It is a large tree, has a fine grain, is beautifully veined, and is the most valuable of the American kinds for furniture."

FISH CULTURE.—XIII.

By Greville Fennell.

WHITSTABLE OYSTERS—NATIVE GROUNDS—PRIVATE OYSTER-BEDS—LICENCES—NATURAL AND ARTIFICIAL OYSTER-BEDS—WORKING—REPORT OF MM. NICOLLE AND LE HUGUET ON THE FRENCH OYSTER FISHERIES.

It is impossible at present to say to what cause or combination of causes is to be attributed the great superiority of natives over all other oysters. The most remarkable circumstance connected with the native beds is that they are all situated on the "London clay," or on geological formations of similar character. Beginning on the Kent shore, the native beds extend westward at irregular intervals from Ramsgate—the modern representative of Roman *Rutupia*, celebrated in ancient times for its famous "Rutupians"—to Sheerness and Queenborough, and eastward on the Essex coast and its rivers from Leigh to Harwich harbour. Oyster-beds in every other part of the country are considered beds of common oysters. Many of the best known beds of native oysters are, to a very great extent, factitious. They possess no certain power of reproduction, and would soon become exhausted, unless supplied with brood from other beds better situated for the retention of spawn and the production of spat. Of this kind are the celebrated Whitstable oyster-beds, where a good fall of spat is a mere accident, which, however, sometimes puts as much as £30,000 in the pockets of the Whitstable Oyster Company in one year, by rendering the purchase of brood unnecessary. No artificial contrivances of any kind are in use on those beds for saving the spawn, which is left to settle by chance on the cultch of the beds or on the adjoining foreshores, or else to be drifted off to sea and lost.

Certain of the native grounds—as, for instance, "The Pont" at the mouth of the Colne and Blackwater rivers—are, on the other hand, remarkable for furnishing an apparently inexhaustible supply of spat, from which, in the shape of brood, the Whitstable and other Kent and Essex oyster-beds are mainly kept stocked. This product, so precious for the maintenance of the Thames oyster-beds, has recently risen greatly in value, having been sold in the seasons of 1862-63 as high as 40s. per bushel, and during late years at a considerably higher rate.

Private oyster-beds are those which from time immemorial have been in the exclusive possession of individuals or companies, and are marked out by buoys or other boundaries. All other oyster-beds are public property, and open to all. On account of the present state of the law in England relative to navigable waters, the existing private beds, being situated below low-water mark, are limited to those of ancient date, because there exists at present no power to restrain any one from appropriating oysters bred naturally or laid down in places not held by prescriptive or other recognised right. In Ireland, however, the Commissioners of Fisheries have been recently empowered to grant licences, under the Crown, for the exclusive right of growing and fishing oysters in places suited for the purpose, to which no prior claims are found to exist.

WORKING BY DREDGE FROM BOATS.

The same state of things exists with regard to the foreshores, of which the Crown claims to have control, with exception only of such as have been ceded by grant or otherwise. In certain districts, and more particularly in the estuary of the Thames, the Crown has to a very great extent lost or disposed of its rights to the foreshores, which have consequently become the private property of the adjoining landowners. In places where this is the case, the foreshores are in general carefully preserved by their proprietors, for the sake of the periwinkles, cockles, and mussels which they produce, as well as for the laying during the summer months of common oysters to fatten for sale in the following season. Natural beds, properly so called, are for the most part beds of common oysters, and generally public property. They are always situated beyond low-water mark, and are seldom covered with less than three

feet of water at low ebb. Some beds of native oysters, however, are true natural beds: to this category belong the principal Colne grounds. But those beds which require to be kept in stock by the laying down of extraneous brood cannot be reckoned truly natural. The latter hold an intermediate position between natural beds, properly so called, and those of strictly artificial character, none of which have hitherto been formed in this country. Artificial oyster-beds, properly so called, are those in which reproduction is secured by artificial means. With the single exception of the ancient Roman oyster-beds, situated in the Lake of Fusaro, they are of modern creation.

Working is an operation by which the oysters are greatly improved. It consists in detaching the brood from the cultch, separating young oysters when joined together, destroying star-fish, dog-whelks, and other vermin, as well as in removing, by stirring it up, the ooze, or "sludge," which is liable to settle on the beds and smother the oysters. On beds situated beyond low-water mark working has to be done in boats, by dredging, and requires as many as eight men per acre. Beds on the foreshores are worked by men on foot, armed with rakes, two of whom suffice to keep in order one acre of artificial oyster-beds. Working by dredge from boats, besides being less certainly efficacious than working on ebb-dry ground, owing to the beds being hidden from view, has the additional disadvantage of being destructive to the tender spat and brood, which are readily injured by the passage of the heavy dredge along the bottom. The illustration in the preceding page will show how dredging or working by dredge from boats is carried on, and the shape of the dredge employed in oyster fisheries, which is a strong frame of iron furnished with a scraper at the bottom to tear the oysters from the bed, and a net which receives the oysters torn off by the scraper.

Frost, which is destructive to oysters, is prevented injuring the stock on artificial beds by arranging the surface in such a way as to retain about a foot of water at ebb-tide. The experience of the French in this respect is borne out by that of the proprietors of some of the foreshores where spat falls naturally from time to time in uncertain quantities. They find that such spat can always be preserved and reared, even in the most severe winters, on those portions of their grounds where the water, when at its lowest, lies a foot deep, or even less.

The average rate of reproduction obtained in France by artificial breeding arrangements is about fourteenfold, which, after paying expenses, leaves a clear profit of 1,000 per cent. Though affording an extremely handsome return, this result still exhibits an enormous amount of waste, which further improvements in the means of arresting and fixing the spawn will no doubt greatly lessen, and to that extent augment the profits to be derived from artificial oyster-breeding.

The following is an abstract of a report made by Messrs. Nicolle and Le Huguet to the committee appointed by the States of Jersey to inquire into the condition of the French oyster fisheries:—

"On the island of Ré an incredible quantity of oysters has been produced on a sea-shore which a few years ago was of no value, so that this branch of industry now realises extraordinary revenues, and spreads comfort among a large number of families who were previously in a state of comparative indigence.

"At St. Martin the authorities have established model oyster-beds, where we saw the upper parts and sides of stones covered with oysters, in numbers almost incredible, and of remarkable beauty. At low water, when the beds are uncovered, the sight is magnificent. Here we made the acquaintance of Dr. Kemmerer, a man of some standing, who employs much of his time in the breeding of oysters, and who has published a work of a very interesting nature on the subject. It appears that this industry, which now forms a source of great riches for that small place, only dates from 1858. In the short period which has since elapsed upwards of 2,000 beds have been formed on an extent of five miles of foreshore. These beds, of 30 yards square, cost £12 each for their construction.

"The Commissary of Marine at Teste, in the Bay of Arcachon, conducted us to some beds which are very prosperous, and where workmen were employed in detaching the young oysters from each other, in order to give them room to grow. We met the proprietor of one of those beds, who had laid down on them 500,000 oysters scarcely three years ago, and he now estimates the return at not less than 7,000,000.

"We then visited St. Brieuc, where hardly two years since parent oysters were deposited on beds which had become exhausted. Already a single bed has yielded 17,000,000 of young oysters, besides a multitude of others of smaller size."

The fattening of oysters in "claires" is thus described by MM. Coste and Kemmerer, and forms a distinct industry to that of breeding:—

"At Marennes, the mud-ponds, called 'claires,' resemble so many fields overflown with water, established in different places along the two banks of the river Seudre, extending over several leagues along the shores, and forming an immense estate, where a curious and lucrative trade is carried on, the State sanctioning its development by concessions of ground made to fishermen who wish to cultivate it. The 'claires' differ from the ordinary oyster-parks, or breeding-ground, because they are not submerged as the parks are at each tide, but only at high tides, when the sea rises to a sufficient height to cover them, as a too frequent submersion would be an obstacle to the object of the undertaking. Each 'claire' is from twenty-five to thirty yards square, surrounded with a bank of earth about three feet in height and in thickness, forming a dyke upon which the guards walk, thereby to watch and protect their work.

"The marly ground, which is considered the perfection of oyster-ground, is that on which the oyster takes a perfect form, and fattens quickly. We say quickly, because the end and aim of oyster-culture should be for the oyster to obtain perfection as rapidly as possible. We should consider the mud-ponds only as requisite for the growth and fattening the oyster.

"The oysters on the rocky shore are meagre, not very agreeable in taste, and have no nutritive qualities. But they fatten these oysters in parks for sale for all the markets of Europe, under the name of oysters of Ostend, Cancale, Dunkirk, and English natives. When this oyster is fattened it is agreeable to the palate, but still has no positive nutritive qualities. This shore-oyster, however, has had the honour of being cited by Pliny, Cicero, Horace, and Seneca; they were eaten in large quantities by the Africans and Chinese. Our modern people of Paris eat 132,000,000, costing 2,214,344 francs (£88,573). The Roman Sergius entertained the high society of Rome upon them. Marshal Junot ate three hundred before breakfast. But the culture of this oyster in the mud-ponds and in the marl—a culture which ought, some day, to become general—changes completely its qualities, the albumen becomes fatty, yellow or green, oily, and of an exquisite flavour. The animal and phosphoric matter increases, as does the osmazome. This oyster, when fed, becomes exquisite food. In effecting the culture of the sea-shores, and of the marl-ponds, we are pursuing a practical principle of great importance, by the conversion of millions of shore-oysters (squandered without profit) into food for public consumption. The green oyster, to this day, has only been regarded as a luxury for the tables of the rich, but we would like to see it used for food for every one.

"We have proved that the mud-ponds are feeding-grounds to which all the young oysters should be conveyed, and in which are found all the requisite elements for bringing them to perfection.

"The shore-oyster can only be eaten during a few months; the oyster of the mud-ponds, on the contrary, can be eaten during nine months. We thus double the quantity of oysters for the public consumption. Government does not hesitate to modify the law on this point. When we have learnt how to cultivate oysters, the shores will have their crops of these valuable mollusks from Médoc to Bordelais.

"When you wish to partake of oysters, you may seek in the mud-ponds, so justly renowned, of Ars and of Loix to obtain the oyster which is unrivalled, and you will then know the exquisite and unctuous taste which this excellent mollusk gives.

"In the marl the young oyster finds plenty of food, constant heat, and perfect quiet; wherever there is mud and sun, there will be found the little mollusks, crustacea, and swarming infusoria, which are the food of the oyster. This is the ground on which they will grow the quickest.

"In cultivating only the oyster-seed upon the shores, you will have two elements of success in your industry; the first, in saving a great part of the young, which would otherwise be destroyed; the second, in making saleable oysters in three years at the most, when four years are necessary for the oysters in the slimy parks."

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XVI.—FINANCIAL DETAILS—ADMISSION TO STUDIES.

Financial Details.—It is remarkable that no uniform system prevails at our public scientific institutions for payment for acquisitions. At one museum the curator is at liberty to purchase at discretion any specimens he approves "on the nail," if under the value of £5; while at another he is allowed to spend £10 a month on his own responsibility. For larger amounts, at one museum purchases are recommended by the curator to the governing council, and if approved are paid immediately after the next council meeting that follows the delivery of the specimens; at another purchases made during the quarter are paid for immediately after the turn of quarter-day; while at the British Museum, both keeper and seller meet with considerable delay, if not difficulty, before a purchase over £10 is effected, much to the disadvantage of that institution, as dealer, collectors, etc., who have once experienced inconvenience, especially those who make but a temporary stay in London, offer their best specimens to those museums which are promptest in settlement, a great number of the collectors being poor men. Thus, a keeper of a department has to make his recommendation of purchase; this has to pass through the hands of the superintendent and the principal librarian before it reaches the trustees; and, as Professor Maskelyne remarked, in his evidence before the Parliamentary Committee, is open to "be smothered on its way," a matter that ought to be provided against by rules, even if such an occurrence is not probable. If the sub-committee of trustees accept the purchase on the keeper's recommendation, the authorisation of the standing committee has to be obtained next, and then the signature of an order for payment, which often entails great delay before a purchase is completed; and if a collection is at last declined, it leads to such dissatisfaction that I have heard collectors say they would never again take specimens for sale to the British Museum.

Another financial arrangement that works objectionably is the system involving the forfeiture of any balance from the previous annual Parliamentary grant to a public institution, if vouchers of payment cannot be produced for purchases authorised under that grant, which might arise through the non-completion of an order. At one institution the period for accounting for the annual grant comes so close upon the time at which that particular institution has to make its application for it, that its officers are forced *to pay* for goods, collections, and specimens which they have been authorised to purchase, before *it is possible* to get the orders for the same executed and delivered, in order to obtain the vouchers of purchase, and prevent the annual grant being lost to them by the bearing of this financial rule on the want of uniformity of system among institutions whose requirements are of an allied character. A board of management, composed of the keepers, under the chairmanship of the director, might determine the amount required for the purchase of specimens, new fittings, books, instruments, etc., in their several departments, to enable the director to make application for such items, in lump, in his annual report. Each department could, on the passing of the grant, be credited in the director's account books, and debited with all purchases made; each keeper being authorised to make direct orders for payment on the director up to the extent of their grant, for all purchases they desire to make, whatever the amount. This simple system might well replace the present cumbrous, tedious, and unsatisfactory manner of effecting purchases, which is at the same time derogatory to the official position of the keepers. The unutilised balances from the several departments might, toward the end of the official year, be disposed of in bulk by the director on any class of objects the circumstances of the moment might dictate to his judgment. Provision should also be afforded for securing the temporary services of any travelling naturalist, who had attained eminence by special investigations, particularly in regard to new species, etc., etc. for the purpose of verifying the museum specimens pertaining thereto, as such verified specimens could afterwards be treated as "author's types," in the same way as Professor Maskelyne judiciously availed himself, a few years since, of the invaluable services of Dr. Victor von Lang, colleague of the lamented Grailick, of the Vienna Mineralogical Museum, for the verification of the crystallographic and optical characters of the minerals under his charge.

It is a question whether the keepers ought not, in annual rotation, to be allowed a grant for visiting foreign collections, museums, etc., connected with their own departments, not only for the purpose of keeping themselves *au courant* with what was doing elsewhere, but with the object of securing specimens by exchange or purchase not otherwise attainable.

A surveyor would report on the cost of repairs, etc., which, with the item of salaries and requisition for desiderata, would be communicated to Parliament in the annual report of the Director.

Admission to the Studies.—In the same manner as tickets are now granted to literary men for admission to the reading-room of the British Museum by the principal librarian, so should tickets for access to the studies be granted to students in natural history, by the Director of the new museum, either on his personal knowledge of their being Fellows of scientific societies, naturalists by repute, or on the recommendation of one of the keepers, assistant keepers, or any member of the staff of a scientific school from their personal knowledge, with one important exception. At the British Museum there is an established rule that persons under age are ineligible for admission to the library. This would be judicious if acted on in the spirit rather than to the letter of the law, if it were intended to give power to exclude youths and girls who only desire access for the purpose of reading novels, love-poems, etc.; but it is used, to my personal knowledge, to the extent of excluding infants-at-law who seek entrance for the earnest purpose of gaining a living.

Two years since I commissioned seven artists to make copies, at the British Museum, from certain works required for the Russian Government, the object of which was explained to the library officials, who, with their usual courtesy, gave every facility for the work being executed, and all my draughtsmen received tickets of admission. Among the number was a young but promising artist, who, after some weeks' work, unconscious of this rule, stated in conversation to an official that he was not yet twenty-one. Unfortunate *lapsus linguæ!*—his ticket was immediately confiscated, and he was deprived of earning from ten to thirty shillings for every copy he could make from works only accessible in a national library. Such a frightful attack of "the red-tape worm" upon an infant is worthy of the attention of the body of trustees; and is worth quoting as a warning to those who may have to frame the rules for the government of the studies not to put any such restriction upon age, as long as youths can bring testimony of industrious zeal for the pursuit of natural history.

In concluding this series of articles on the "Construction, Arrangement, and Management of a National Museum of Natural History," I have endeavoured to show that the ideas of the leading naturalists of the present day could readily be embodied in one building; and it is to be hoped that party feeling will not mar the attainment of this desirable end, but that men of influence will unite with "a pull altogether" in a rational and national spirit to further the excellent intentions of the Government, for it rests with them whether a museum suited to the wants of the age shall now be attained, or the opportunity lost for ever. It would have been more satisfactory if the approved plans had been submitted to a committee of British naturalists before builders were invited to send in tenders for the work to be executed; for on such a very important question it would have been well to know that the plans even of such an eminent curator and *savant* as Professor Owen met with the entire approval of all who have given serious and disinterested thought to this subject, and that such plans left nothing to be desired; especially when, on one occasion in the House of Commons, on an inquiry being made by Lord Elcho as to when the plans relating to another building, the new Law Courts, would be submitted to members interested in the matter, he was informed by Mr. Ayrton that he "had made that inquiry just four years too late," and that the subject could not be re-opened. Professor Flower well says, in his article in "Nature," previously quoted:—"Long and extensive experience has, or ought to have, taught us the best principle of construction as applied to libraries and picture galleries; but the natural history sciences are in their infancy as compared

with literature and art, and the best methods by which their treasures can be housed and exhibited have yet to be learned. *The way in which this is done in the new museum will exercise so great an influence upon the progress of these sciences*, that it should not be determined upon without full consideration by those who are most conversant with their present state, and with the probable wants of a future generation of students."

Not even the fear that, by such an elicitation of the opinion of England's leading naturalists, further delay might arise should prevent Government from ascertaining in the most positive manner possible that in those plans all had been provided that could be provided for "arranging, preserving, and exhibiting in a fitting manner a natural history collection worthy of the country as well as of its capital, and intended not only for the special advantage of students and scientific men, but generally for the rational amusement and instruction of all classes;"* for, as Agassiz says, State museums "should be sanctuaries revealing the advances of the sciences, which, by their very perfection, would be a standard measure by which to test the scientific culture of a country."†

SHIP-BUILDING.—XXII.

BY W. H. WHITE,
Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE RIVETING OF IRON SHIPS (*continued*).

In this article we propose to give a brief account of that method of procedure in arranging butt-fastenings which appears, on the whole, to give the best results; and our endeavour will be to make the process intelligible to all readers having any acquaintance with iron ship-building. All, or nearly all, butt-fastenings in an iron ship may be arranged under two heads: the first, those used to connect the lengths of a single strake of plating, such as a deck-stringer or tie-plate, as well as of a single bar of any form; and the second, those used to connect butted plates in an assemblage of plating, like the outside skin, or the plating of an iron deck. For our purpose, therefore, it will be sufficient to take a representative case under each head; and we will begin with a deck-stringer plate, say $3\frac{1}{4}$ feet wide, and $\frac{5}{8}$-inch thick, riveted to the beams with $\frac{3}{4}$-inch rivets, as shown in Figs. 59, 60, 61.

The weakened sections, which are to be our chief guides, in this case occur at the rows of holes in wake of the beams. On reference to the sketches it will be seen that there are seven rivets in each row; hence to find the strength of the stringer at the weakened section we proceed as follows:—

	inches.
Total breadth of stringer-plate . . .	39
Deduct for 7 rivets ($7 \times \frac{3}{4}''$) . . .	$5\frac{1}{4}$
	$33\frac{3}{4}$
Thickness of stringer-plate . . .	$\frac{5}{8}$
Sectional area of plate at weakened section	$21\frac{3}{32}$ sq. in.

Taking 18 tons per square inch as the breaking strength of the stringer-plate after the holes have been punched, we obtain finally—

$$\begin{array}{l} \text{Breaking strength of stringer-plate} \\ \text{at weakened section} \end{array} \Bigg\} = \underset{\text{sq. in.}}{21\tfrac{3}{32}} \times \underset{\text{tons.}}{18} = \underset{\text{tons.}}{379\tfrac{11}{16}}$$

Assuming that the rivets used in the butt-fastenings are to be of $\frac{3}{4}$-inch diameter, we take Mr. Reed's figures of 10 tons for the single shear, and 18 tons for the double shear of each finished rivet; and to ensure the double shear we shall require a butt-strap below as well as above the stringer, while a single butt-strap will suffice to secure a single shear. Obviously, if the butt-fastening is to be as strong as the weakened section, the shearing strength of the rivets on either side of the butt must equal the breaking strength just calculated. Hence we have—

Number of rivets required on each side of the butt:—

$$\text{For a single shear} = \frac{379\frac{11}{16}}{10} = 38 \text{ say.}$$

$$\text{For a double shear} = \frac{379\frac{11}{16}}{18} = 22 \text{ say.}$$

The next question is, what shall be the arrangement of these rivets, and taking into account the breadth of the stringer-plate it becomes obvious that treble-riveting would be required with a single butt-strap. This arrangement is shown in Fig. 60, but it is essentially defective; because it makes the section of the stringer-plate in wake of the row of rivets in the strap furthest from the butt considerably weaker than the unavoidably weakened sections at the beams. A reference to the sketch will make this obvious, for there are no less than thirteen rivet-holes punched in the specified row of the butt-fastening, whereas there are seven only at each of the weakened lines on the beams; and consequently the plate would break across at its weakest section in wake of the outer row of closely spaced rivets, if it were put under tension, long before the strain would be sufficient to shear off the rivets on one side of the butt, or to break the plate across its weakened sections at the beam. This plan, therefore, will not do.

Taking double butt-straps, and consequently a double shear of the rivets, twenty-two only are required, and these might be arranged double-chain fashion, as in Fig. 59; but here again the weakest section of the plate would be found in wake of the row of rivets next the edge of the butt-strap, just as in the preceding arrangement, and consequently this plan is defective.

From these two trials it will be obvious that an essential feature of any proper arrangement must be to make the number of rivets in the rows furthest from the butts not greater than that in each row on the beams. This consideration would, of course, be one of the first taken into account in practice, but we have preferred to enforce its importance by examples. In Fig. 61 it has been applied, and we have at length a satisfactory arrangement of the rivets. Altogether, there are twenty-three on each side of the butt, and their shearing strength, for double shear, is 414 tons—that is, about 35 tons greater than the breaking strength in wake of the beam-rivets. At the rows of rivets furthest from the butts there are only six holes, as against seven at the unavoidably weakened sections on the beams. Other methods of opening the butt under tensile strains may be imagined, but they will be found to involve a greater breaking strength than the foregoing, supposing the butt-straps to be made strong enough to resist fracture. For instance, if the plate broke across at the middle row of rivet-holes in the strap, then the row of rivets furthest from the butt would all have to be double-sheared before the butt could open; and if fracture took place across the more closely-spaced rows of holes nearest the butt, then the two other rows of rivets would have to be double-sheared. The reader can, if he chooses, calculate for himself the breaking strengths corresponding to these two methods of fracture, and will find them both greater than the strength of the unavoidably weakened sections of the stringer.

One other consideration remains—viz., the requisite thickness of the butt-straps. The critical line of fracture for the straps is clearly that through the row of rivet-holes nearest the butt, because if both straps were broken thereat, the butt would be opened. The total length of the supposed line of fracture (rivet-holes being deducted) is $30\frac{3}{4}$ inches; and our first calculation gave $21\frac{3}{32}$ square inches as the sectional area of the stringer at its necessarily weakened section. It will therefore evidently be sufficient to make the sectional area of the two straps at the supposed line of fracture equal to $21\frac{3}{32}$ square inches, and this gives a total thickness of $\dfrac{21\frac{3}{32}}{30\frac{3}{4}} = \cdot 7$ nearly, rather less than $\frac{3}{4}$-inch, so that ample strength will be obtained if each strap is made $\frac{3}{8}$-inch thick.

With an example of this detailed character before them, our readers will have no difficulty in applying a similar method to other cases where a single strake of plating is used as a longitudinal strengthening—for instance, to the longitudinal frames, the tie-plates on deck-beams, the sheer and bilge strakes of composite ships, etc. etc.; and will be able to deal with the butt-strapping of bars used for keelsons, etc.

Attention must next be turned to a typical case of butt-fastenings for a strake of plating associated with and connected to other strakes, with regard to which its butts are shifted. An example in point is given in Fig. 62, which shows an inside view of a portion of the skin-plating of an ordinary iron ship. We will assume that there are *two* passing strakes between consecutive butts in the same frame-space (as in the shift illustrated by Fig. 36, Vol. III., p. 305); so that it will be perfectly

* Treasury Minute of 1862.

† Report of 1860.

fair to consider the passing strakes P and R as assisting the butted strake Q, and to consider those three strakes apart from the remainder of the plating when dealing with the fastenings of the butt A B. Of course, with a different number of passing strakes between consecutive butts, different assumptions would be required, but these need not be discussed here.

It will be assumed that all the plates are $\frac{3}{4}$-inch thick, and $3\frac{1}{2}$ feet broad; also that the rivets are of 1 inch diameter. The strength of the plates in wake of a row of punched holes will be taken as before at 18 tons per square inch of sectional area, and the shearing strength (single) of a 1-inch rivet will be

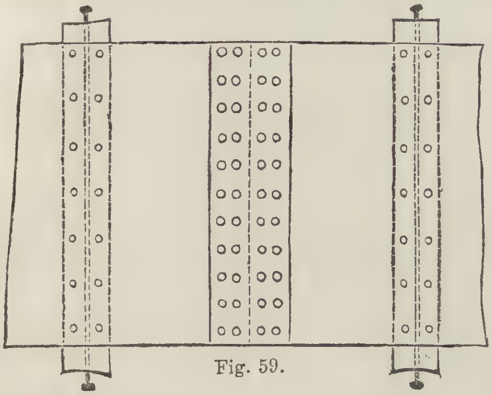


Fig. 59.

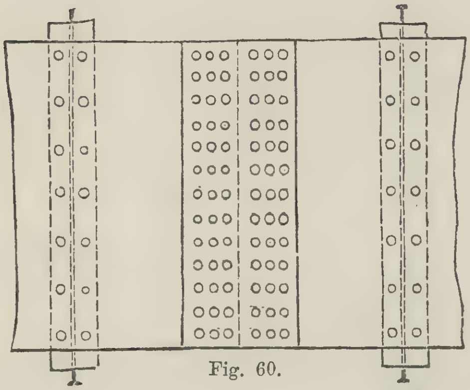


Fig. 60.

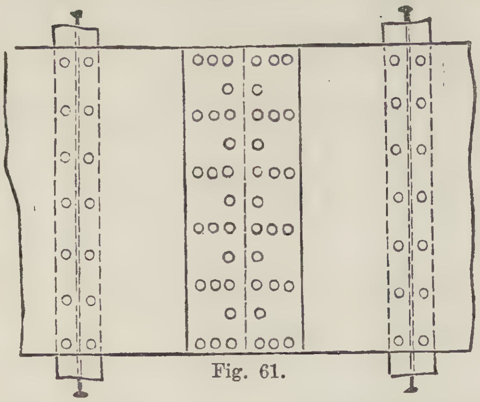


Fig. 61.

taken at $17\frac{4}{5}$ tons (see page 135). For the sake of simplicity also it may be assumed that the frame angle-irons are removed, and the plating alone considered, the necessarily weakened sections (such as C D) being, of course, retained.

Let us first consider how the butt A B is most likely to open under tensile strains, remembering that the edge-riveting between A and E, and B and F, is necessarily arranged in something like the fashion shown in the sketch in order to make water-tight work.

It may open by shearing all the rivets on one side of the butt, and also shearing the edge-rivets just referred to; or it may open by breaking the butt-strap across the row of rivet holes nearest the butt, and also shearing the edge-rivets. In either case the shearing strength of the edge-rivets helps the butt, and it is this fact which constitutes an important difference between a butted strake in an assemblage, and one standing alone like the stringer-plate previously considered. There are, of course, other possible modes of fracture, but none more probable than the two just mentioned. Assuming for the present that this statement is correct, we will proceed to calculate the

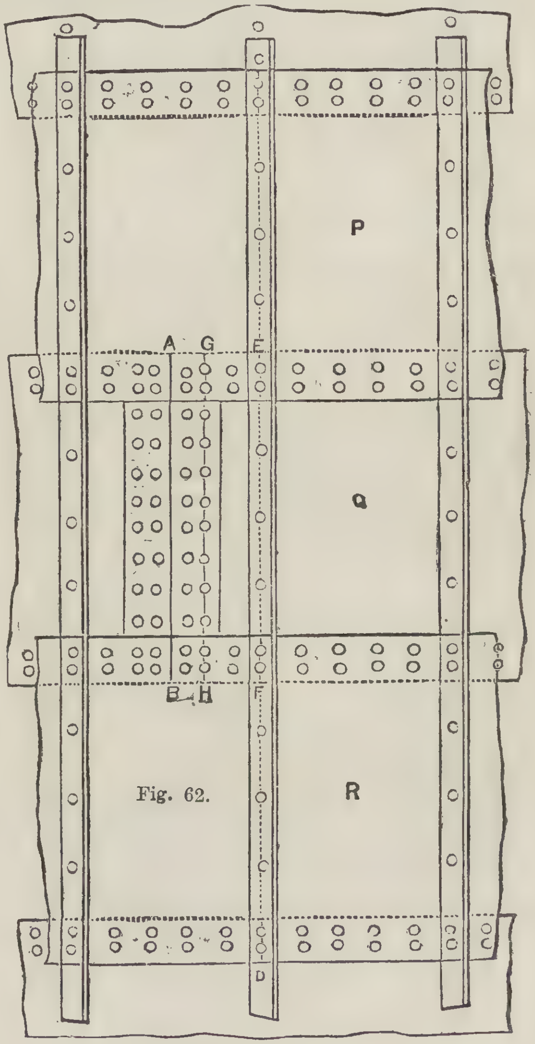


Fig. 62.

strength required in the butt A B to make it equal to the necessarily weakened section of the strake Q (along E F) in wake of the frame. We have—

Total breadth of butted strake Q	42	inches.
Deduct for 7 rivet-holes in line E F	7	"
	35	"
Thickness of plating . .	$\frac{3}{4}$	
Sectional area of Q at line E F	$26\frac{1}{4}$	sq. ins.
	18	tons.
Breaking strength of Q at line E F	$472\frac{1}{2}$	tons.

There are twelve rivets requiring to be sheared in the edges between A and E, B and F, and their total strength $= 12 \times 17\frac{4}{5} = 213\frac{3}{5}$ tons. Deducting this from the breaking strength

just calculated, we have $(472\frac{1}{2} - 213\frac{1}{3})$ say 260 tons, as the minimum strength which should be given either to the shear of the rivets on one side of the butt, or to the butt-strap across the row of rivets next the butt. Hence we obtain the following values:—

$$\left.\begin{array}{r}\text{Number of rivets required on}\\ \text{one side of the butt}\end{array}\right\} = \frac{260}{17\frac{7}{9}} \quad .6 \text{ say.}$$

$$\left.\begin{array}{r}\text{Sectional area of strap through}\\ \text{supposed line of fracture}\end{array}\right\} = \frac{260}{18} = 14\tfrac{1}{2} \text{ sq. in.}$$

Double-chain riveting will therefore suffice, as shown in the sketch; and to ascertain the thickness of strap required we must make another simple calculation. As Q is an *outside* strake, the butt-strap does not extend over the whole width of the strake, but only between the edges of P and R. So that—

	inches.
Total breadth of strap	30
Deduct for 8 rivets	8
Breadth remaining at supposed line of fracture	22

$$\text{Therefore the thickness of strap required} = \frac{14\frac{1}{2} \text{ sq. in.}}{22 \text{ in.}} = \cdot 66 \text{ nearly.}$$

In other words, a strap as thick as the plating ($\frac{3}{4}$-inch) will give rather more than the strength required. From this example it will be seen how unnecessary were the elaborate devices formerly used (see Figs. 42, 43, Vol. III., p. 352) for securing the butts of outside strakes across the whole breadth; and also that there was good reason for asserting that with the simple plan now used, it was sufficient to fit straps of equal thickness with the plating.

The preceding simple calculations are really all that are commonly required, but we will take another method of breaking in order to show that the arrangement made is satisfactory. Suppose the butted plate Q to break across at the row of rivet-holes G H, next the edge of the butt-strap, we shall have—

Total breadth of Q	42	inches
Deduct for 12 rivets in line G H .	12	„
	30	„
Thickness of plate	$\frac{3}{4}$	„
Sectional area of Q at line G H .	$22\frac{1}{2}$	sq. ins
	18	tons
Breaking strength of Q at ditto .	405	tons
Add for shear of 4 rivets in edges between G and E, H and F	$71\frac{1}{9}$	
	$476\frac{1}{9}$	tons

and this is still a little greater than the strength of the unavoidably weak section at E F. It may be added that in cases where the frame-space is small, as in the example we have just considered (Fig. 62), it is advisable always to test this latter method of fracture, in order to make sure that it gives a breaking strain not less than that of the unavoidably weakened section. Other modes of fracture will also suggest themselves to any person engaged in such work, and it should be ascertained beyond doubt that in all essential respects the arrangement made is satisfactory.

The foregoing method is not put forward as one admitting of no improvement, but rather as the best yet known for use in practice, and as embodying the best data accessible up to the present time. It is identical in principle with that used in the Government service; and in building the ships of the Navy, great care is always taken to have good arrangements of butt-fastenings, combining the required strength with the minimum weight of material.

It is only necessary to remark that the simple plan of calculation just described for the outside plating is as applicable to other assemblages, and is made use of for iron decks, flats, etc. etc. Into the minor modifications necessary under different circumstances it is needless for us here to enter, as any person undertaking the work will experience no difficulty in making the necessary changes. Enough has been said in the course of the present paper to guide any one who is studying these principles theoretically and practically, to the proper method of doing so.

SANITARY ENGINEERING.—XXVII.

THE EFFECT OF SANITARY IMPROVEMENTS UPON THE HEALTH OF THE POPULATION.

BEFORE concluding our present series, which we shall do in our next paper, we propose to lay before our readers some reliable data as to the result of the introduction of improved methods of water-supply and drainage upon the health of the population at large. The question has been the object of Government inquiry during a series of years, and the subject of frequent legislation, into the detail of which, however, we do not propose to go, considering it rather beyond the strict range of THE TECHNICAL EDUCATOR. We think, however, our subject will hardly be complete without some allusion to the practical general effect of the various appliances which, in the preceding papers of this series, have been described and illustrated in as full detail as the space at our command allowed.

Some of our figures are extracted from the Ninth Report of the Medical Officer of the Privy Council, dated 1867.

The diseases most directly referable to the want of efficient sanitary arrangements are cholera, typhoid and other fevers, diarrhœa, and in a less marked degree consumption. With regard to the first named, medical men hold various opinions as to the different forms of the disease, English and Asiatic as they are termed, but the cause of both is now almost distinctly ascertained to be cholera contagium in foul air, foul earth, or foul water; and the report says, "Practically the chain of evil (*i.e.* the progress and spread of cholera) is abruptly broken wherever thorough cleanliness prevails," and a most important element is the pureness of the water-supply. A terrible epidemic at the east end of London was distinctly traced to the fact of a company, under the pressure of peculiar circumstances, having supplied a district with unfiltered water, and this, if not the original cause of the outbreak, had much to do with its development and aggravated character. We may mention that similar neglect now subjects the company to a penalty. In our paper No. XV, on water-supply, will be found other parallel cases.

Cholera, however, happily is only an occasional visitant, but typhoid fever and endemic diarrhœa are always more or less with us; and a striking instance of the universality of liability which is incurred by the neglect of sanitary precautions, has recently been shown in the anxiety caused throughout the nation—we might almost say throughout the world—by a single case in the highest family in the land. The deaths from typhoid fever are from 15,000 to 20,000 per annum, and those from diarrhœa probably as numerous.

Consumption is a complaint peculiarly incident to the English climate, and though its first cause differs in character from the diseases previously mentioned, arising mainly from unwholesome humidity in the air, yet the returns we shall presently quote show a marked control exercised over it by complete sanitary arrangements. In the words of the report, "The drying of the soil, which has in most cases accompanied the laying of main sewers in the improved towns, has led to the diminution more or less considerable of phthisis." These are the three most distinctly recognisable evils directly under the control of sanitary measures, but there are a number of other maladies dependent most materially upon good air, good water, and good drainage for their considerable diminution. Our space will not, however, allow us to go into further detail.

First as to cholera, there have been three recent epidemics of which the results have been noted occurring in the years 1849, 1854, and 1866; and we give the comparative death-rate in various towns as recorded in the different years. In Cardiff the death-rate by cholera in 1848-9 was 208, in 1854 it was 66, and in 1866 it was $15\frac{1}{2}$; it may be mentioned that the medical officer of the town was most efficient. In Newport, the death-rate by cholera in 1848-9 was 112, and in 1866, 12. Sanitary improvements thoroughly carried out in the intervals referred to are to be credited with this marvellous improvement. The cholera rate in Dover was in 1849, 40; in 1854, 10; and in 1866, $4\frac{1}{2}$. At Cheltenham the corresponding figures are 82, 11, and $1\frac{1}{2}$; at Salisbury, 180, $14\frac{2}{3}$, and "perhaps" 1.

We might multiply instances, but think we have quoted enough, our object being to prove the general fact only, not attempting a complete statement of detail. We next take the case of typhoid fever and diarrhœa. Here we have, of course,

no such exact data to guide us as in the case of cholera, but can only give the decrease of the death-rate as obtained by comparison before and after the completion of the sanitary works. In Croydon they fell from 25 to 12½; in Macclesfield, from 25½ to 19½; in Salisbury, from 14 to 4; in Cardiff, before quoted, 17½ to 10½.

In typhoid fever alone the death-rate fell in Warwick from 19 to 9; Penrith, 10 to 4½; Stratford, 12½ to 4; Alnwick, 13⅓ to 8⅔; Morpeth, 16½ to 10; Ashby, 13⅓ to 5¾. The great difference in the earlier figures among the various towns will no doubt attract attention, their situation, soil, and the habits of their population all having their effect upon the general result. Did space allow, some curious facts might be deduced as to the comparative salubrity of different strata and situation.

We now take up our next head, that of phthisis. The reduction in the death-rates is stated as under:—Salisbury, 49 per cent.; Ely, 47 per cent.; Rugby, 43; Banbury, 41; Worthing, 36; Macclesfield, 31; Leicester, 32; Newport, 32; Cheltenham, 26; Bristol, 22; Dover, 20; Warwick, 19; Croydon, 17; Cardiff, 17; Merthyr, 11. Here we should, to complete the comparison, give the previous death-rate, but we content ourselves in this case by merely stating the result. Such are the actual certified results of improved sanitary arrangements, due not only to the introduction of improved methods of drainage and water-supply, but to the efficient organisation of a certain system of inspection and control. Into the details of this organisation we are not proposing to go: we may merely mention that in some of our principal towns it is carried out with almost military completeness and efficiency, and point out the arrangements adopted by the corporation of the City of London as a model in this respect. There is an engineer for the constructional and practical department with an efficient staff of subordinates, a medical officer for the higher branches of hygiene proper, and a large body of inspectors, whose duties are clearly defined and regularly mapped out, exercise a salutary control in their various districts.

But in many of our provincial towns there is still much to be done, and a single case in point we quote from a report published a few years ago, by Dr. Ballard, who was employed by Government for the purpose, remarking that the conditions he described were by no means peculiar to Bolton, but would be equally applicable to many other manufacturing towns. Paper-works, dye-works, and various mills discharging their refuse into the rivers; the working classes penned closely together in ill-built, crowded localities; close courts behind the houses sometimes unpaved; the absence of sufficient closet accommodation; and the total want of organised sanitary inspection, had all their share in conducing to the evil, the marked existence of which led to the special inquiry—viz., an exceptionally high death-rate. The greatest cause of mischief was the almost universal use of middens: for 16,000 houses there were only 500 closets; there was a system of main drainage in operation, but it was perfectly clear that under the circumstances it might almost be called a mockery as far as sanitary arrangements were concerned. More than 2,000 houses had been built within the last ten years, mostly of cottage character, and they possessed all the worst faults of the lowest character of building—inefficient foundations, utter absence of house drainage, incomplete ventilation, the windows in their lower portion not even made to open, in some cases the sleeping-room of a whole family built without fire-place or chimney—in fact, many of the houses in the town were unfit for human habitation.

From this report, and from much similar evidence at our command, we cannot help drawing the inference that private enterprise will never be sufficient to provide efficiently for the general sanitary arrangements of the country. Much may be done by private and personal efforts by persons in a position to understand and efficiently attend to many of the necessary details of sanitary matters. And we recall the celebrated dictum of a late noble lord, in which he impressed upon the working classes the necessity for their personal attention to these matters; but there is an immense body of the lower portion of the population who have not the knowledge, and even if they had, do not possess the power of protecting themselves. And here we have no doubt of the great desirability of Government interference. The chaos in which sanitary and other legislation and organisation are plunged throughout the country was fully detailed in the Second Report of the Royal Sanitary Commission issued a few years ago; and although an analysis of its contents is beyond the scope of THE TECHNICAL EDUCATOR, we strongly recommend its perusal by all engineers, medical officers, and others interested in the subject. The improved health of the localities where efficient sanitary improvements have been carried out, quoted in the earlier portion of this paper, is a most striking fact, and the promotion of such improvements is clearly the duty of each and all of us. The 28th, our succeeding and final paper, will be devoted to a summary of the subject, indicating in a few lines the leading matter of each of this series of papers, embraced under the four heads of Gas, Warming, Ventilation, and Drainage, so that those interested in any particular subject may readily refer to the paper containing the details they require.

TECHNICAL DRAWING.—LXXXIV.

DRAWING FOR CABINET-MAKERS.

WOODS USED IN CABINET-MAKING (*continued*).

ROSEWOOD

Is a wood much employed in cabinet work, but is too expensive for general use; its name is derived from its fragrance, and it has long been known to the cabinet-makers of England and France. It is said to have been first introduced from the isle of Cyprus, though the great supply now comes from Brazil. The wood is too well known to require any description. The more distinct the darker parts are from the purple-red, which forms the ground, the more is the wood esteemed. It is ordinarily cut into veneers for all the larger furniture, such as tables; but is used solid for chairs, small tables and cabinets.

(*) "Rosewood is produced in the Brazils, the Canary Isles, the East Indies, and Africa. It is imported in very large slabs, or the halves of trees, that average 18 inches wide. The best is from Rio de Janeiro, the second quality from Bahia, and the commonest from the East Indies; the latter is called East India black-wood, although it happens to be the lightest and most red of the three; it is devoid of the powerful smell of the true rosewood, which Dr. Lindley considers to be a species of mimosa. The pores of the East India rosewood appear to contain less or none of the resinous matter in which the odour like that of the flower *Acacia armata* arises. Rosewood contains so much gum and oil, that small splinters make excellent matches.

"The colours of rosewood are from light hazel to deep purple, or nearly black; the tints are sometimes abruptly contrasted, at other times striped or nearly uniform. The wood is very heavy, some specimens are close and fine in the grain, while others are as open as coarse mahogany, or, rather, are more abundant in veins; the black streaks are sometimes particularly hard, and are very destructive to the tools."

OAK.

In point of strength, durability, and general application, the oak claims the precedence of all timber, and to England, which has risen to the highest rank amongst the nations through her "wooden walls," it has always been of the greatest importance. Although, since the improvement in our methods of working iron, it is not now so much used for ships as formerly, it is still for building purposes and for furniture as valuable a wood as ever.

The oak grows to an enormous size, attaining frequently a height ranging from 80 to 100 feet, with a trunk from 6 to 12 feet or more in circumference. Of this important wood Mr. Holtzapffel says: (*) "Of this valuable timber there are two kinds common to England, and several others to the Continent and America. Oak of good quality is more durable than any wood that attains the same size. Its colour is a well-known brown. Oak is a most valuable wood for ship-building, carpentry, frames, and works requiring great strength or exposure to the weather; also for the staves of casks, spokes of wheels, for tree-nails, and numerous small works. The red varieties are inferior, and are only employed for ornamental furniture. The English oak is one of the hardest of the species; it is considerably harder than the American, called white and red Canada oak, or than the wainscot oak, from Memel, Dantzic, and Riga. The latter, which are the most interspersed with the ornamental markings or flower of the septa, or medullary rings in the wood, are the least suitable as timber."

MAPLE.

Of the maple (*Acer*) there are about thirty-six species, natives of various countries. Six are indigenous to Europe, about twelve to America, and the remainder to various parts of Asia. Most of them are deciduous trees, but one is an evergreen shrub. It will be necessary to notice only two—the great maple, or mock-plane (*Acer pseudo-platanus*), and the American sugar-maple (*Acer saccharinum*)—the first on account of its timber, and the last on account of its sap.

The great maple, called also the sycamore, and the plane-tree, is hardy, stands the salt spray of the sea better than most trees, grows rapidly and to a great height. The timber is very close and compact, easily cut, and not liable either to splinter or warp. Sometimes it is of uniform colour, and sometimes it is very beautifully curled and mottled. In the latter state, as it takes a fine polish and bears varnishing well, it is much used for certain parts of musical instruments. Maple does not contain any of those hard particles which are injurious to tools, and is therefore employed for cutting-boards; and not being apt to warp, either with variations of heat or of moisture, it is an eligible material for saddle-trees, wooden dishes, founders' patterns, and many other articles of similar character. Before the general introduction of pottery ware, it was the common material for bowls and platters of all sorts, and some are even now made of it. As the juice of the maple, both in the leaves and in the tree, is sweet, it attracts numbers of insects. At certain seasons the wild bees and wasps may be seen about it in crowds; and if the timber be placed so that insects are allowed to settle upon it, the worm speedily attacks it. When kept dry and free from this evil, it will last a considerable time; but exposed to humidity it is one of the most perishable of trees.

THE OAK (*Quercus sessiliflora*).

SATIN-WOOD.

This beautiful wood, which has a light canary-yellow colour and satiny lustre, is imported chiefly from Nassau, in New Providence, one of the Bahama Islands. It comes in square logs about 10 feet in length, and about 8 inches square, and is used only for furniture and small fancy articles of cabinet-work.

AMBOYNA-WOOD

is also called Kyabuca or Kyabooca wood. There are several varieties of it to be found in our timber-yards; "they are probably all furnished (says Mr. Archer) by the same tree (*Pterospermum Indicum*)." It is most beautifully mottled and curled, of various tints, from light red to dark yellow, and always in small lumps, being evidently excrescences or wens cut from the trees. The varieties of Amboyna wood are principally used for inlaying, and by the makers of snuff-boxes.

BLACK EBONY.

This well-known black wood is very hard, heavy, and susceptible of a high polish. It is imported in sticks rarely more than 4 inches square, and 4 feet in length. About eighty tons are annually brought to this country. (Archer.)

CHERRY.

The wood of the cherry is very close, and in some sorts of a beautiful colour, and well adapted for the handles of tools. It takes a fine polish, and is not liable to split. Some of the bird-cherries are beautifully veined, and have an agreeable perfume, on which account they are much used by cabinet-makers, especially in the interior parts of the Continent. None of the cherries grow to be very large trees, but they may be frequently met with from a foot to 18 inches diameter at the root.

BEECH.

Like the chestnut, the beech thrives best in rich soils and sheltered situations, and when planted in suitable places, it is a beautiful as well as a valuable tree. The close texture of the beech renders it a very fit timber for machinery, for the stocks and handles of tools, and for many other purposes. It is not proof against the worm, however, and when exposed to alternate draught and moisture it soon decays. Against a cross-strain,

too, it is not so strong as the grained timbers. Although easily turned, it is not well adapted for large or hollow objects, as it is apt to split when drying.

(*) Only one species (*Fagus sylvatica*) is common to Europe. In England the Buckinghamshire and Sussex beech are esteemed the best.

Beech is stained to imitate rosewood and ebony, and is considered to be chemically free from foreign matters; for example, the glass-blowers use the wood almost exclusively in welding or fusing on the handles of glass jugs, which process fails when the smallest portion of sulphur, etc., is present. Oak is next in estimation for the purpose.

BIRCH.

This tree is a native of cold and inhospitable climates, and the dwarf birch is the last tree that is found as we approach the snow in elevated regions. Naturalists affirm that the birch-trees constitute the principal attraction to the birds which are found in such plenty in high northern latitudes.

(*) It is an excellent wood for the turner, being light-coloured, compact, and easily worked. It is in general softer and darker than beech, and unlike it in grain.

Birch-wood is not very durable; it is considerably used in furniture. Some of the wood is almost as handsomely figured as Honduras mahogany, and when coloured and varnished it is not easily distinguished from it.

The English birch is much smaller than the foreign, and lighter in colour; it is chiefly used for common turnery. Some of the Russian birch (called Russian maple) is very beautiful, and of a full yellow colour.

CEDAR.

(*) The name cedar has been given to trees of very different natural orders, and has occasioned much confusion. The cedar of Lebanon, or great cedar (*Pinus cedrus*), is a cone-bearing, resinous tree, and one of the pines. It is tall and majestic, and grows to a great size. The mean dimensions of its trunk are 50 feet high and 39 inches diameter. The wood is of a rich yellowish-brown, straight-grained, and has a peculiar odour. The tree is famous in Scripture for its size and durability. It was used in the construction of Solomon's Temple in Jerusalem, and many Grecian temples and statues. A few fine trees are said still to remain on Mount Lebanon, but the wood was also procured in the time of Vitruvius from other parts of Syria, and from Crete, Africa, etc. (Tredgold.)

The pencil cedar is the *Juniperus Virgineana*. It is also of the same nature as the pine-tree. It is imported from North America in pieces from 6 to 10 inches square. The grain of the wood is remarkably regular and soft, on which accounts principally it is used for the manufacture of pencils, and, from its agreeable scent, for the inside work of small cabinets. From the same reason it is made into matches for the drawing-room.

THE CEDAR OF LEBANON (*Pinus cedrus*).

The cedar known to cabinet-makers by the name of Havannah cedar is the wood of the *Cedrela odorata* of Linnæus, and belongs to the same natural order as mahogany, which it resembles, although it is softer and paler, without any variety of colour. This tree often grows to a height of more than eighty feet, with a trunk of very great thickness. Its wood is imported in considerable quantity from the island of Cuba, and is excellent for the insides of drawers and wardrobes. All the cigar-boxes from Havannah are made of this kind of cedar. The wood is brittle and porous. Some kinds of the Havannah cedar are not proper for cabinet-work, as the gum oozes out and makes the surface of the work very sticky and unpleasant. Of this cedar also much wood is used in the manufacture of lead-pencils.

The limits of these papers preclude our giving a description of the other kinds of cedar, and of the "fancy woods" mentioned in our list. For the history of these the student is referred to other works devoted to this special branch of the subject.

PATENTS AND PATENT LAW.—V.

By A Barrister.

INFRINGEMENT.

The three obvious modes by which a patent may be infringed are these :—(1) By making the patented article ; (2) by using the patented article ; (3) by a sale of the patented article. We have used the term "patented article" in each instance, because it would appear that a sale of the *product* of the patented article would not be an infringement, unless the vendor is in any way connected with the use of the machine, when, apparently, it would be otherwise. So at least it has been decided. And it has also been held that the sale of the thing patented to an agent of the patentee is not, *per se*, an infringement, although it may be evidence of an infringement if accompanied by other circumstances. The American Judge Story decided also that the mere making of a patented machine for use or sale, though it were, in fact, neither used nor sold, is an infringement, for which, however, only nominal damages can be recovered, but that the making merely for experiment or philosophical purposes is not an infringement. This view was adopted by our English Judge Patteson.

The more important head is the second, namely, the user of the patented article. The American author Phillips, from whom we have already quoted, says that a use of the patented article is a direct and unquestionable infringement. The same writer makes some sensible observations on the distinction to be drawn between the contrivance and the actual production. "The art, contrivance, or design," he says, "considered abstractly, is not itself patentable, or an infringement of a patent. It is only in its production, in combination with materials, that it is either patentable itself, or a violation of a patent right. In a patented instrument or piece of machinery the subject of the patent exists, and is visible and tangible, and admits of being possessed and delivered distinctly and independently of its products. But when a composition of matter is the thing patented, the subject of the patent is identified with its products, or rather a specimen of the product, or the only vendible thing which it is the object of the invention to supply, is at the same time a specimen of the invention itself; whereas, in the case of an instrument or machine, one object of the invention is to produce the instrument or machine itself, another to produce its products. The inventor of a loom may propose a profit on the sale of it, as well as on the sale of its product. So again, a steam-engine, like a loom, is invented to be used as an instrument until it is worn out; and in this respect, both differ from a patent medicine or many chemical compositions which are consumed and destroyed at once in the use." He contends that the use of a patented article which is consumed in the use, and of one which lasts a long time, is equally an infringement. Thereupon he proceeds to inquire what is the use, and who may be said to use the article? In the case of a patented paint, can the lessee who occupies a house painted with the patented article be said to use it? or can the lessee or purchaser of a chaise varnished with patented varnish be said to use the varnish? In either case he answers in the negative. The person who selects and applies the article is the person who uses it. So the doctor or the apothecary, not the patient, uses the patent medicine; but where the article is durable it is otherwise, as the cultivator uses a plough, and a manufacturer a loom, and so they, no less than the vendor, infringe the patent right.

We may usefully accept from the hands of the learned author some principles established in the summary of American cases which he gives. First, then, the person who uses an article to which a patented improvement is attached, uses the improvement so as to infringe the patent. A mere contract to purchase the articles produced by the instrument is not a constructive use of it by the purchaser. And as already suggested, a use of the patented article merely for philosophical experiment, or for the purpose of ascertaining "the merit and exactness of the specification," is not an infringement. That a patent cannot be infringed by anything done before it is granted, is a self-evident proposition.

The above is American law, but it coincides with our own. To show that this is so, we will refer to the famous case which we have already consulted for other purposes, the case of Betts's patent for capsules for bottled beer, which will well illustrate what is meant by the use of a patented article amounting to an infringement. There the point was, whether there was an infringement in England to which only the letters patent extended. It was proved that the beer was bottled in Scotland, and then sent through England to places abroad. It was insisted that this was no infringement of the patent in England; that the sale of the capsuled bottled beer took place in Scotland; that it was merely *in itinere* in England; that in its resting-place with the English agents there was no active *use* of the patented article which could constitute an infringement. The Lord Chancellor (Chelmsford) said, "A variety of cases were supposed in argument to show to what extravagant consequences a decision against the defendants would lead. It was asked whether if the beer was sent by sea, and arrived at an English port, and was there transhipped for exportation without being landed, there would be an user of the capsules in England; or whether, if there were a patent for a particular dye, and a lady were to purchase a dress in Paris dyed with the patented colour, and then to wear it in this country, she would be guilty of an infringement." His lordship regarded these as extreme cases not likely to arise for legal decision, but he observed that he could see no distinction in principle between the patented article being placed in a warehouse on land, and the ship in which it is brought from Scotland being made the warehouse until it can be put on board another vessel for exportation. And as to the suggested case of the patented dye, he pointed out that there might be some difficulty in dealing with the case of the ignorant use of a patented invention under such circumstances. Lord Chelmsford then proceeds to deal with the particular case on principle. He remarked :—"The infringement of a patent is a tort, and all persons who are in any way acting towards it are jointly answerable. If, then, the mere presence of the capsuled bottles in England amounts to an user of the plaintiff's invention, Messrs. Tennant, who send the beer into England, are parties to the infringement, whether they derive profit from this course of transmission or not. . . . I do not appreciate the distinction which was pressed upon me in argument between an active and a passive use of a thing." He referred to a case of an alleged infringement of a screw-propeller, and said, "This screw-propeller in the one case, though in motion during its use, was just as passive an agent as the capsules in the present case. *It is the employment of the machine or the article for the purposes for which it was designed by the persons so employing it that constitutes its active use.* Whether the capsules were intended for ornament, or for protection of the contents of the bottles upon which they were placed, the whole time they were in England they may be correctly said to be in active use for the very objects for which they were placed upon the bottles by the vendors. If the beer, after being purchased in Glasgow, had been sent into England, and had afterwards been sold here, there can be no doubt, I suppose, that there would have been an infringement, because it would have been a profitable user of the invention. I cannot see how it can cease to be an user, because England is not the final destination of the beer, if the capsules while they are in this country are upon the bottles, doing their duty (whatever that may be), for which they were placed upon them."

It is scarcely necessary to point out the important principles established by this judgment; but for those who do not follow the judgment, we may state that there may be an infringement by the active though unprofitable use of the patented article, and that active use simply means the employment of the article in the ordinary manner designed by the inventor, and that the mere presence of the patented article in the geographical limits to which the letters patent extend in such use is an infringement. In this case, in the Court of the Lords Justices of Appeal, one of the learned judges said that he could see no distinction between the active and the passive use of a patented article.

In a somewhat similar case at common law, in which some remarks were incidentally made on the interesting question of an infringement by a person ignorant of the existence of the patent, the subject generally was discussed by the judges of the Court of Common Pleas. The facts in this case were that the articles alleged to be an infringement of the English patent were imported from abroad, having been manufactured in a foreign country. We are brought by this case to the consideration of infringement by sale. Chief-Justice Erle, in the course of his

judgment, said, "I have heard the arguments of the learned counsel on both sides derived from the original statute which uses the words 'work and make,' and the form of the expression about working, making, or putting in practice, and the introduction of the words 'vending,' 'make, use, exercise, or vend.' . . . It appears to me to have been clearly the intention in the grant of the privilege to prohibit a party vending the patented article for the purpose of profit by the selling. It is the main purpose of the patent to give the profit to the patentee, and the main mode of defeating that would be by selling a patented article; and it does seem, without proof of the making of the article by the infringer, if he sold the patented article for profit, it may be good evidence upon which a jury may find that he had infringed the patent." Then as to the question of the defendant not being liable for the sale of articles because they were imported from abroad, his lordship added, "I should say that, even if it was a simple case of importation without any proof of knowledge that it was a patented article, or knowledge of the infringement, that would be sufficient evidence of infringement to charge the party with infringing, if he had imported or sold."

This question of ignorance is important, as it may appear hard that an innocent person should suffer the penalties of infringement. It has, however, been distinctly laid down that a use of one process in ignorance that it is capable of being accurately represented as an imitation of an earlier invention is an infringement. This is illustrated by a very recent case with reference to a patent for plaited frills or trimmings. Wilcox had taken out a patent, and Orr adopted a process which, unknown to the defendants, was an infringement of Wilcox's patent. They were yet held guilty of an infringement by buying and selling the goods made by Orr's process. This point as to selling is very important, and is distinctly dealt with by Lord Chief Baron Kelly, who said, "The statute does not certainly contain the word 'vend,' which is found in the grants of patents, but we may have some regard to the constant usage according to which for 200 years patents have contained an express licence to use and vend; and although the use of this word by the Crown is not conclusive upon the construction of the statute, it would be strange that for so long a time every patent should have purported to confer the exclusive right and interest if the grant were unauthorised. . . . It may be that in most, if not all of the cases when narrowly examined, it appears that the defendants had some part in the manufacturing as well as in the selling of the article. But if it is now necessary to decide the point, I am clearly of opinion that if a man takes out a patent by means of which an article is made at a considerably less cost than the same article was before produced at, one who buys and sells such articles—I do not say on a single occasion, for each case must be determined on its own circumstances, but when he becomes in the way of trade a buyer and seller of quantities of such articles—knowing them to be manufactured by a machine which is, *de facto*, though unknown to him, itself an infringement, such buying and selling is an infringement by him of the patent. . . . It is impossible to suppose that an exclusive right to vend is not given, and the defendants have therefore infringed the plaintiff's right, *and it is immaterial whether it was or was not known to them that Orr's machine was identical with the plaintiff's.*"

There being no doubt about a case of actual sale, there might be a doubt where the article is manufactured and offered for sale, but no sale is effected. It is said to have been laid down, although this does not clearly appear to be the case, that this would amount to an infringement. On the principle, however, that where the intending vendor is connected with the use of the machine, the sale is an infringement, it would seem to be good law. On the other hand, it has been expressly decided that merely "exhibiting to sale" imitations of an invention is not any infringement of the patent.

We will now proceed to consider the case of the infringement of a portion of a patent, that is to say, the use of a part of a combination. To begin with, let us state the effect of three leading decisions. An infringement of any part of a patent process is actionable, if that part is of itself new and useful, so as that it might be the subject-matter of a patent, and is used by the infringer to effect the object proposed either wholly or partially by the patentee. A patent for an entire combination is not infringed by a different combination, for the same object, of the same elements, though important, or of equivalents for them, if not a mere colourable evasion or imitation. If a patent is taken out for an invention by means of a combination, the use of a subordinate part of the combination is no infringement of the patent, unless such part is new and material. Then as regards the exportation of parts of a patented machine, the rule has been laid down, that though the manufacture in this country of the several parts of a patented machine, and the exportation of those parts may not be an infringement of the patent, the machine being the novelty and the parts being old, it is otherwise where the part exported is itself the patented invention. The general principle as to the infringement of parts is, that where a patent is for an invention consisting of several parts, the imitation of any part of the invention is an infringement of the patent.

This being a point of some nicety, we will give an illustration. The specification of a patent for improvements in wheels described the invention as consisting of a mode of forming a wheel of one solid piece of wrought iron, by means of welding pieces of wrought iron together, so as to form the iron spoke and nave into one compact mass. The defendants in the case used a wheel made by welding pieces of wrought iron together so as to form a single compact piece of wrought iron; the mode of forming the nave was the same as that in the specification; the mode of forming the rim was different. It was decided that as it appeared that the mode of forming the nave was a material, new, and useful part of the invention, the use of it by the defendants was an infringement of the patent, although in the specification, after describing the whole structure, the invention was stated to consist in the circumstance of the centre boss or nave, arms and rim of the wheel, being wholly composed of wrought iron welded into one solid mass "in manner hereinbefore described." The judge at the trial of the case intimated his opinion that the claim was for the invention of a wheel as described in the specification; but that if the defendant had imitated or pirated the mode of welding the nave, and that were a material part of the invention, there was an infringement of part of the patent, for which the action was maintainable. The full court concurred in this view, and go on to say, "Where a patent is for a combination of two, three, or more old inventions, a user of any of them would not be an infringement of the patent; but where there is an invention consisting of several parts, the imitation or pirating of any part of the invention is an infringement of the patent. Suppose that a man invents a machine consisting of three parts, of which one is a very useful invention, and the two others are found to be of less practical use, surely it could not be said that it was free to any person to use the useful part so long as he took care to substitute some other mode of carrying out the *less useful parts* of the invention."

The leading case on this subject was heard in 1866 before the House of Lords, and had reference to "improvements in certain machines for spinning and doubling cotton and other fibrous substances of the kind commonly known as mules and twiners." The plaintiff there contended that the defendant had infringed the patent of his machine. It was there recognised that the ordinary courts are not suitable for the trial of patent cases. The Lord Chancellor said, "It is extremely difficult in questions of this description for an unscientific person to arrive at a satisfactory conclusion, as he is sure to be perplexed with the contradictory opinions which the skilled witnesses on both sides invariably oppose to each other." The important point was that the two machines brought out different results, and the same learned lord said, "Upon a question of combination, the action of two machines with differently disposed parts, *differing so materially from each other in their different effects*, almost necessarily leads to the conclusion that there must be a substantial difference between them." The argument in support of the infringement was that whatever the effect was, the means by which it was attained in each case were substantially the same. In spite, however, of the resemblances, three courts decided against the alleged infringement. Any one who desires to see what a fight between two patentees means should look at the report of this case of Curtis *v.* Platt reported before the House of Lords in 35 Law Journal Reports, Chancery, at page 852.

It is not our province in these papers to give an exhaustive reference to every species of infringement to be found in the

decided cases, and we believe we have done sufficient to show with tolerable completeness what under different conditions may and what may not amount to an infringement. We will now simply refer to the place where an infringement may take place. It has already been shown by reference to the case of the capsules for bottled beer, that the mere fact of being on board ship in English waters for the purpose of transhipment may be an infringement of an English patent. To take a case on the other side of the question. Mr. Newall obtained a patent for "improvements in apparatus employed in laying down submarine electric telegraph wires," and by his specification and drawing annexed gave a full description of the manner in which it was to be performed. The patent was limited to the United Kingdom, the Channel Islands, and the Isle of Man. The infringements of which Newall complained occurred on board ships which had been prepared by the defendants for the purpose of laying down a submarine electric telegraph cable between Rangoon and Singapore. Ultimately the cable was laid between Malta and Alexandria. The court found that nothing had been done in England amounting to an infringement, and counsel did not argue upon what had been done at Malta. But Baron Bramwell addressed himself to this point. "I am clearly of opinion," he said, "without going into any elaborate consideration of how far a vessel of a country is the territory of a country, the doctrine cannot be carried so far as to make anything done abroad an infringement of letters patent, which are in their terms limited to the United Kingdom, the Channel Islands, and the Isle of Man."

Before proceeding to notice the means of obtaining redress for an infringement of a patent—in other words, to inform our readers of the nature of a patent suit—we may briefly state what is the measure of damages to be awarded, so that a patentee may know what to expect before commencing proceedings. He may, of course, obtain an injunction. He may also obtain a decree for damages. A good deal depends upon the circumstances of the case, but it has been recently decided that a patentee of an invention who, himself a manufacturer, has been in the habit of licensing the use of his invention by other manufacturers on payment of a fixed royalty for each machine, having obtained a decree for damages "by reason of the using or vending" of the invention, is not entitled to claim by way of damages any sum beyond the ordinary royalty. Hence he is not entitled to claim, in addition to his ordinary royalty, a manufacturing profit; and, *à fortiori*, not such a manufacturing profit as he would have made if every unlicensed machine had been sent to him to be fitted with the invention. From this example an opinion may be formed as to the probable result where the circumstances are different.

CIVIL ENGINEERING.—XXI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

PILES AND PILE-DRIVING.

THE value and importance of piles in the consolidation of an insufficiently compact soil which it is intended to make the foundation of a structure, and their absolute necessity in forming the foundation of almost every kind of marine engineering work, except, indeed, when the solid rock becomes itself the foundation, renders a careful consideration of the subject not only desirable but necessary, and we cannot do better than take it up at the present period, and before introducing the important subject of bridges, whose stability is so greatly dependent upon the character of their foundation.

In the course of our remarks upon docks it will have been observed that reference was frequently made to two classes of piles—those placed *beneath* the walls, and those standing in *front* of them. The former are the main-piles, the latter the sheeting-piles. The main piles are driven into the super-soils until their lower extremity reaches the more solid stratum. When it may be necessary to cease to drive a pile is a point which must be left to the discretion of the engineer.

No engineer would commence a work of any magnitude without first satisfying himself, by boring, of the nature and depth of the various strata beneath the proposed structure, and upon the result of these borings he will base his arrangements for piling. A few words respecting the piles themselves. The size and quality of piles will depend upon the soil and the work they have to do. If of timber, they are either of oak, elm, beech, or fir; if the last named, either Dantzic, Memel, or red American. They should be perfectly sound, formed of the straightest timber, the fibres being in no way twisted, and of an even scantling throughout. They are pointed at the lower extremity and shod with wrought-iron shoes, and to prevent their splitting under the blows of the ram they should have strong iron hoops encompassing their upper end.

It is essential to bear in mind that timber piles, although capable of remaining in a sound condition for ages under the simple action of water, are nevertheless in many situations liable to rapid destruction from the attacks of the *Teredo navalis*, a worm which is able to bore into fir timber with incredible rapidity, and which has caused in more than one instance the entire destruction of an arch supported wholly on timber struts. The action of this worm is always greatest when the water is salt or brackish. The size or scantling of piles will vary somewhat with their length; if of oak, their diameter is usually about the twentieth part of their length. The distance apart at which piles should be driven is an important matter. The use of a pile is twofold, for not only does it transmit the solidity of the sub-soil upon which it rests to the superstructure, but compresses, and therefore consolidates, the soil around it. The closer piles are driven together the greater is the compression of the soil, because, being displaced by the timber, it is necessarily forced away laterally. For this reason it is always advisable in driving the piles for a heavy superstructure, such as the pier or abutment of a bridge, and in any case where it is intended to place the piles near together, to commence with the central row, and to work outwards from these, first upon one side and then upon the other, so as gradually and evenly to force away the soil, and thus to render it very firm on all sides of the intended structure.

In driving piles deep it is natural to expect that the deeper they descend into the soil the greater will be the force needed to drive them. This results not only from the increasing density of the sub-soil, supposing it not to vary in the character of the strata, but also from the increased friction upon the sides of the timber. It is important, however, to bear in mind that extreme force being required in driving a pile is not to be regarded as a certain proof of a firm bottom having been reached. In clay, for instance, the pile sometimes becomes a conductor of water, which finds its way along the sides, softening the clay and rendering it greasy, and gradually permitting the pile to settle deeper, and, indeed, rendering the piled foundation less secure than the natural clay base would have been. In such a case certain unyielding nuclei should be established by piles driven a few feet apart, the intervals being subsequently filled in with other piles driven as closely together as possible. The depth at which a pile should be driven is a point, we have said, to be decided upon by the engineer after careful consideration of all the circumstances of soil and subsequent weight to be borne. Piles, well driven into good holding ground, will, if placed about 4 feet apart from centre to centre, sustain the weight of any pier. A single pile of 12 inches diameter will, if well driven in good soil, bear with safety a load not exceeding 50 tons, and one of 9 inches diameter a load of 25 tons.

It may sometimes be desirable to incline the direction of the outer piles of a foundation with their bases outwards, by which arrangement a very efficient support is given to the interior piles, and any tendency they may possess to swerve from the perpendicular under the weight of the superstructure is prevented.

The heads of piles for bridge-work should be cut off near the surface of the ground, level and even, and the soil be removed from between them, if not driven closely together, to a depth of 9 inches or a foot, and the space filled in with concrete to the level of the heads. This will generally be found to form the best basement for the masonry of the building.

Sheet-piling varies from 4 to 6 inches in thickness, and about 12 inches in width. When they are intended for the facing of a wall it is seldom necessary to drive them as deep into the soil as the main piles; the necessity or otherwise of shoeing them with iron must depend upon the soil. They may require to unite closely with each other at their sides, and in such cases there is a groove formed in the side of each to receive a plank.

The machinery employed for driving a pile is an important

feature in engineering. The length of time consumed in driving piles is very considerable, and it is desirable to accelerate the process by every available means. The progress of invention in this respect has been gradual. All pile-driving engines are based upon the principle of percussion, a weight more or less heavy being raised vertically over the head of the pile, and allowed to fall upon it through a greater or less space. When the piles to be driven are short, and the ground comparatively yielding, a heavy wooden *beetle* or maul is employed. It is simply a block of hard wood hooped with iron, and furnished with one or more handles radiating sufficiently from the centre to enable each handle to be grasped by a man, the united action of several being thus available for raising a heavy weight and imparting a powerful blow. But such an arrangement is entirely useless when much pile-driving has to be accomplished, and the piles are of a large size.

The pile-driving engine is of two kinds: that worked by manual or horse-power, and that in which steam is employed as the motive power. A manual pile-driver consists of a block of iron termed a "monkey," furnished with studs or projections to fit into grooves in the timber framing, in which it works vertically, and by which it is guided in its course. The size of the monkey varies from 2 to 12 cwt., or even more according to the work to be done. If small, it is raised by a single rope passing over a pulley at the top of the frame, and finally divided into several ends, at each of which a man is stationed, and by whose united effort the weight is raised and allowed to fall. When the monkey is large it is set in a framework of wood standing vertically upon a base formed of several timbers framed and bolted to the uprights at right angles, and to which is securely attached a crab. A strong pulley is placed at the upper end of the vertical timbers over which passes the chain by which the monkey is raised. The longer end of the chain passes round the cylinder of the crab, which is furnished with two handles worked by several men. An inclined ladder, fixed in the diagonal of the framework, affords access to the pulley and upper parts of the machine. The guides in which the monkey works are plated with iron to resist the wear and tear due to the repeated passage of the block. Nippers, similar to those shown in Fig. 48, are attached to the free end of the chain, and serve to connect the chain to the ring of the monkey. When the monkey has been raised to a sufficient height the upper arms of the nippers are contracted by entering a wedge-shaped opening, and the lower jaws opened, thus releasing the monkey, which falls by gravity through the space intervening between its maximum height and the top of the pile. Immediately the monkey is released, the pawls of the crab are released, and the nippers and chain descend by their own weight, and the lower sides of the jaws of the nippers being bevelled, open as they touch the ring of the crab, and close when they have embraced it, so that the duties of the men are confined to the simple work of raising the monkey and letting the chain follow it after it has fallen. As the pile continues to sink into the soil the distance between it and the raised monkey increases, and the blow delivered is therefore heavier. But the time occupied in raising the weight is increased, although not in proportion to the advantage gained, since the velocity of the falling weight is as the square root of the height, whereas the time occupied in raising it is directly as the height only. It will be useful to insert a table showing the value of the blow of a ram falling through various heights. As the ram may be supposed to fall $16\frac{1}{2}$ feet in a second, according to the laws of gravity in this latitude, it is easy to calculate its velocity in falling through any given height, assuming it to be proportionate directly to the time of its descent. The velocity acquired at the end of the first second is equal to $32\frac{1}{6}$ feet in a second, at which speed it enters upon the fall through the third second, and so on. It is, therefore, only necessary to multiply the force in the column of *force*, in the subjoined table, by the weight of the ram, and the force of the blow is immediately ascertained.

Fig. 48.

For instance, if the ram weigh only 1 *cwt.*, its force in falling through 1 foot = 8 cwt.; if the ram weigh 8 cwt., its force will be $8 \times 8 = 64$ cwt.; and if it weigh 10 cwt., and fall through 10 feet, its force will be $10 \times 25{\cdot}3 = 253$ cwt. The student can easily make further calculations for himself, under different conditions given in the table.

Fall of the ram in feet.	Time of the descent in seconds.	Force in tons of a ram weighing 1 ton.	Fall of the ram in feet.	Time of the descent in seconds.	Force in tons of a ram weighing 1 ton.
1	·25	8·0	21	1·14	36·7
2	·35	11·3	22	1·17	37·6
3	·43	13·9	23	1·20	38·5
4	·50	16·0	24	1·22	39·3
5	·56	17·6	25	1·25	40·1
6	·61	19·6	26	1·27	40·9
7	·66	21·2	27	1·29	41·7
8	·70	22·7	28	1·32	42·4
9	·75	24·1	29	1·34	43·2
10	·79	25·3	30	1·37	43·9
11	·83	26·6	31	1·39	44·6
12	·86	27·8	32	1·41	45·4
13	·90	28·9	33	1·43	46·1
14	·93	30·0	34	1·45	46·8
15	·96	31·0	35	1·48	47·4
16	1·00	32·1	36	1·50	48·1
17	1·03	33·1	37	1·52	48·8
18	1·05	34·0	38	1·54	49·4
19	1·09	35·0	39	1·56	50·1
20	1·11	35·9	40	1·58	50·7

In the arrangement of nippers already alluded to it is necessary that they shall always rise to the height of the contraction before they release hold of the ram. This may not always be convenient, especially when the pile has descended very low. To obviate this defect a hook fitted with a long tail-piece, to which is attached a rope, is sometimes made use of. The hook works laterally on a pivot in connection with the chain, and being heavy, falls naturally into the ring of the ram until withdrawn by a strain being put upon the rope attached to the tail-piece. By this method the ram can be made to descend at any moment required.

The steam pile-driver is a great improvement upon that worked by manual labour. It is in principle precisely similar to a steam-hammer. The steam-cylinder is inverted, and the ram fixed to the head of the piston-rod, which passes out of the lower end of the cylinder. The admission of steam upon the lower side of the piston raises both it and the ram, and the escape-valves being opened simultaneously with the closing of the steam-valve, the ram falls by gravity through the entire height of the cylinder. Its force may be supplemented, if necessary, by the admission of steam above the piston. The power and rapidity of these blows are very great.

Piles are employed in many other situations besides forming the foundation for piers, etc. In those positions they naturally remain; but in many cases, as, for instance, coffer-dams, their use is temporary, and after being no longer required, they have to be withdrawn in order to free the navigation. Sometimes their withdrawal is attended with considerable trouble. Not only is there the friction of the soil to overcome, but the weight of the pile, and the suction of the water, added to the oxidisation of the iron shoe. So considerably, in fact, does the latter cause affect the withdrawal of the pile that in sea-water, where oxidisation is most likely to occur, the iron shoe may with advantage be sometimes omitted. The operation of withdrawal may be greatly assisted by striking the heads of the piles obliquely; indeed, an upward blow given with some heavy body will occasionally have greater effect in moving a pile from its bed than any amount of dead leverage. If the head of the pile is above the water, a strong bolt may be passed through it at a sufficient distance below its top to ensure that no movement of the fibre or splitting of the pile results. To this bolt will be attached the chain for withdrawing the pile. If the head is below water, or in some position where it is impracticable to pass a bolt through it, a strong square iron collar, somewhat larger than the pile, is passed over it, to one side of which the withdrawing chain is attached. The pull is thus given obliquely, and the edges of the collar bedding themselves into the wood prevent its slipping. A screw working in a strong framing, through the head of which capstan-bars are passed, forms a powerful means of withdrawing a pile. A very ordinary method

of accomplishing this in tidal waters is to attach the withdrawing chain to a strong bowsprit projecting over the extremity of a barge, the chain being made taut at low water. As the tide rises the pile will be withdrawn to the extent nearly of the rise of the tide.

When it is intended that piles shall remain as a permanent portion of a foundation it will be necessary to cut their heads off to a given level. Of course, if the foundation be dry, the operation is simple, but when under water a machine of a peculiar construction is necessary. The machine employed at the bridge of Choisy consisted of a horizontal frame, to the centre of which were fixed two upright bars. The saw-blade, which cuts horizontally, was fixed to the lower extremities of the uprights, to the upper ends of which the tightening-bar was attached. The frame was worked backwards and forwards by men, whilst by means of a rope fixed to the lower ends of the uprights another workman applied pressure of the saw against the pile. By means of this machine a pile from 10 to 12 inches square was sawn off in twenty-five minutes by a carpenter and six labourers, the saw-cut being 3 feet 8 inches below the horizontal frame. Machines of a more complex character become necessary when the depth of the saw-cut below the surface of the water is considerable.

ENGLISH CARRIAGE-BUILDING.—II.

BY A LONDON COACH-BUILDER.

AXLES—SIZE AND POSITION OF WHEELS—SPRINGS—FORE-CARRIAGE—FUTCHELLS.

HAVING thus arranged the size and shape of the body, we can decide the length of the axles, the size and position of the wheels, the length and span of the springs, and all the details of the fore-carriage. We want the wheels to be 3 feet 8 inches behind, and 3 feet 2 inches in front. If we refer to Fig. 1, showing the drawing of the brougham on the canvas (page 129), we shall see that we have 2 feet 7 inches to spare between the ground-level and the under part of the pump-handle. Half the height of the wheel will be 1 foot 10 inches; this gives us the position of the hind axle, and, allowing for the thickness of the axle, leaves us barely 8½ inches for the thickness and span of the springs, together with the thickness of block, top and bottom of the spring. This is not sufficient, and shows us where our drawing is faulty, or rather, not properly placed; for a wheel 3 feet 8 inches high, we must therefore give more curve to the pump-handle, by which means we may gain as much extra space as we require without altering the height of our wheels, or without raising the body higher from its present ground-level.

Then, by measuring the height in front, from the ground-level to the bottom of the boot, we shall find we have 3 feet 5 inches to spare. Half the height of the front wheel will be 19 inches, which will leave 10 inches for the span and thickness of springs, half an inch of block top and bottom of springs, and 11 inches for the depth of the fore-carriage, top and bottom, including the bracket blocks.

We must next decide the length of the axletrees. As a general rule, it may be taken for granted that the inside width across the body at the top of the door-rail should be the length of the hind axle, from collar to collar over all. Thus, should the width across the body at this point be 3 feet 8 inches, the length of the axle between the points indicated should be 3 feet 8 inches; the side cant of the body and the turn-under of the standing pillar, together with the set-under of the axletree and the dish of the wheel, will carry the wheel sufficiently out from the side of the body without allowing anything more.

The front axle should be half an inch longer than the hind one, for the wheels to track, because the dish of the front wheel —this wheel being lower than the hind one—will not throw the wheel out on the ground-level so far as the hind. The distance of the hind axle-flaps from collars will be regulated by the width of the body across at the hind bottom sides, where the pump-handles are fixed, and that of the front axle-flaps by the width across at the bottom of the boot.

The next thing is to strike the position of the wheels. The hind ones must be thrown sufficiently far back to allow the door to open freely without touching the wheels, and if the door be hung with concealed hinges, the thickness of the door must be taken into consideration, as the concealed hinges bring the inside of the door flush with the standing pillar when open to the full extent.

To decide the position of the front wheel is not quite so simple. As this has to lock or turn under the arch, the play of the springs, and the length of the axletree, the height of the arch, and the relative height of the wheels, all have to be taken into consideration.

The centre on which the two front wheels revolve as they lock round is the perch-bolt, and the size of the circle they describe is therefore determined by the length from that centre to the tire of the wheel; but while that part of the wheel which comes in contact with the ground is describing one circle on the ground, the back part of the wheel is describing a more extended circle in space. This Fig. 4 will show.

The horizontal line A is the axletree, B is the wheel at rest, C is the wheel on full lock, D is the back of the arch, E is a section of the ground circle the wheel will describe as it moves backward, and F is a section of the circle the back of the wheel will describe in space during the same movement. It will be seen by this, that when the wheel is on half-lock, the back part of it will come in contact with the arch, and that when on full lock it will have travelled right away from it. It follows, therefore, that if we want to find out the right position for the perch-bolt to occupy, we must not measure the circle the wheel will describe on the ground, but the one it will describe in space. We must, therefore, measure along the line F, and carry that measurement up to D.

The diagram here given is to half-inch scale, and the length of the line from A to D is exactly three feet. Now the position of the perch-bolt, or centre-point on which the wheels lock round, need not be, and, as a matter of fact, rarely is, in a line with the axletree. By compassing the beds or timbers on which the fore-part of the body rests, and through which the perch-bolt passes, the centre of the circle described by the lock may be carried forward. Thus, if the beds be compassed four inches forward from the straight line along the axle, the centre will be carried forward four inches, the result of which will be, that when on the half-lock the back part of the wheel will be carried away from the arch two inches, and that when on the full lock the wheel will stand four inches back from the position it would occupy if the bed was straight. The dotted lines below F and E on the diagram will show the result of this difference in the shape of the bed, and it will be seen that in order to get a two-inch clearance of the arch from the back of the wheel without carrying the wheel itself farther forward than three feet from the back of the arch, we must compass the bed four inches, the compass-mark being to the centre of the substance of the bed.

Having arranged all these particulars, we can strike the position of the wheels, we can give their height and dish, the length of axles, with the position of flaps, and the length of arms. We can give the span and the length of the springs, and all the necessary details for the construction of the body in every particular; we have only to make our patterns of the different parts, and prepare our sweeps to enable us to proceed with the whole business of building.

Before a workman could be trusted with the making of a body he must, of course, have considerably advanced in the knowledge of his craft beyond the mere knowledge of the use of his tools. It will not be necessary, therefore, for his benefit, to describe in detail all the different parts that form the framework of the body, nor would such minute detail be interesting to the general reader. It will be sufficient to say, that in marking out the stuff, care should be taken to lay the patterns on the timber, so that the grain run as near as possible in a line with it: thus, if the pattern be straight, the grain of the timber should be straight; if the pattern sweep round, the grain should run with the sweep. Again, some mild or light description of timber should be selected for the door-pillars, and some hard strong timber for the hind bottom sides, where the pump-handles are fixed, as well as for the front-boot bottom sides.

If the foreman who superintends all this be accomplished in his department, and if the workmen on his staff be equally skilful in theirs, the work may be distributed among almost as many men as there are parts in the framework of the body; these parts will be worked up, the mortises and tenons, the rabbets and tongues cut to a specified gauge; and when they are all ready, they will go together like a Chinese puzzle, or a pack of cards.

In the construction of the body the smith plays an important part, and we require some of his best workmanship. All along each bottom side of the body should be plated with iron; this should be of the toughest quality, and the best brand. The edge-plate, as this is technically called, may be regarded as the back-bone of the body. It should run from one extremity to the other, commencing at the hind bottom bar, on to which it should be cranked, and ending at the front part of the front-boot bottom side. This plate should take a perfectly flat bearing at every point. Great care must therefore be taken in fitting it, for although the plate may be of the requisite strength, the absence of this perfect fitting will render it comparatively weak, the result of which will be found when the body is finished and mounted on the wheels, by the springing of the sides, which will cause the pillars of the body to press on the doors.

When the body is finished from the hands of the woodman, it passes into the hands of the currier: a hide of leather is specially prepared for it, and in a soft pulpy state is strained over the roof, the back, and the top quarters of the body, and sleeked down till the surface is perfectly smooth at every point. It is then nailed down and left to dry, which will take several days, after which it passes into the hands of the painter; meanwhile the carriage-work, the wheels, the axles, and the springs, have all been got ready, and the body mounted.

The axles should be made of the best scrap iron fagoted, that is, a number of thin rods of iron should be taken like a bundle of fagots, and twisted and welded together into a solid mass; whether they are so or not may be detected by putting them into the fire, and heated to a red heat. If fagoted, the marks of the different rods running like grain in wood will then be plainly seen; if not, the heated part of the axle will present a perfectly clear and grainless appearance. The advantage of fagoting is the greater amount of strength thus given to the axle; the flaps, which support the springs, should be in the solid, and the axle-arms should be made on Collinge's principle, as no better has yet appeared in the market.

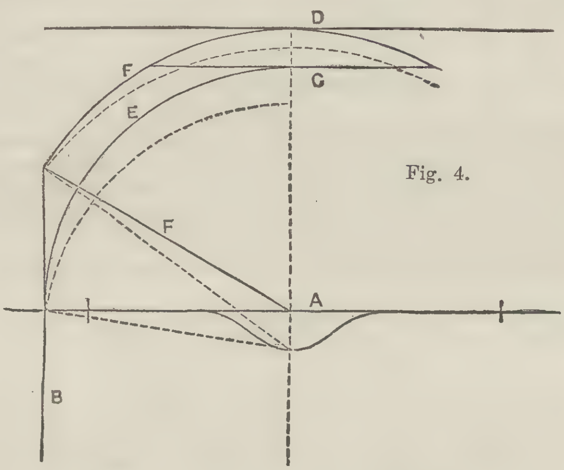


Fig. 4.

The springs should be made of the best spring steel, specially prepared for the purpose by the best makers, and the wheels should be made of good tough elm for the stocks, cleft sapling oak for the spokes, and sound English ash for the felloes.

The carriage part of a vehicle, as distinguished from the body, comprises all that part or those parts on which the body is placed; the term may be said more particularly to apply to what is technically called the fore-carriage, which consists of the top carriage, which is bolted on to the bottom of the flat part of the boot, and the bottom carriage, which carries the front wheels, and is connected with the top carriage by means of the perch-bolt. The timbers of these are named the beds, which we have already indicated as those through which the perch-bolt passes; the horn-bar, which stands at the back of the top bed; and the futchells, which are either opened or closed—the open futchells being those which are made of bent ash, and stand wide apart to carry the shafts when the carriage is to be drawn by one horse only; and the close futchells are those which are made of sawn timber, and brought together to carry the pole when the vehicle is to be drawn by two horses. These different descriptions of under carriages are fitted respectively to what are termed single or pair horse carriages.

All these timbers should be made of sound strong ash, and well plated with iron: indeed, modern taste largely exacts the substitution of iron for timber in this part of a pleasure carriage; and here it is that the skill and taste of the smith are particularly displayed, not only in the fitting and finishing his plates, but in the formation of all that iron-work which connects the different parts of the carriage and springs with each other.

We give in Figs. 5 and 6 designs of two different descriptions of fore-carriages, in order that what we have to say in connection with this department may be more clearly understood. The central circle is the wheel-plate, or, as our American cousins call it, the fifth wheel; this is flat at the bottom and round on the top, and, being fixed to the under part of the top carriage, takes its bearings on the bottom carriage, and by its extended circular formation gives steadiness to the body when the vehicle is running in a straight line, or when the fore-carriage is on full lock. These bearings are at the back ends and the fore part of the futchells, and at those points of the bottom bed which are covered by the wheel-plate. The fore and hind bearings are of ash timber, and are necessarily circular in form.

It will be seen how imperative is the necessity of the wheel-plate being a perfectly true circle, and of taking a perfectly flat bearing; the forging and finishing such a piece of workmanship requires, therefore, peculiar care and skill. In the diagram showing the open futchells, the stays which run from the back end to the front of the futchells are the wheel-irons, the back-stays, and the bed-clips in one. They clip over the ends of the bottom bed, and being at these points made flat, they are cranked downwards to take their bearing on the spring-block, and here they are fixed to the springs, either by means of bolts passing through them, or by clips and couplings. The best plan is by the latter, as when they are bolted on, holes have to be drilled through the springs, which renders them weak at those points; the same may be said of the manner of fixing the bottom half of the spring on to the axletree.

The wheel-iron, bed-clip, and back-stay being in one, affords an opportunity for the smith to display both his skill and taste as a workman, as it is desirable that this piece of workmanship should be both graceful in form, and exceedingly well forged and fitted. When finished, it should fall into its position, taking all its bearings with the greatest ease, for if, in bolting on, it should be subjected to any strain in order to force it to its bearings, it will be liable to snap at the first jar it encounters on a rough road.

But the best efforts of the workman would be counteracted in this respect, if he did not have the best metal to work with, and for this reason the English coach-smith ought to possess a far better knowledge of the art of metallurgy than he does at present. We cannot enlarge here upon the various methods by which he may detect the quality of the material that is placed in his hands to mould and weld into the various forms required in his department; but for all general purposes it is desirable that he should know that perfectly pure iron is so soft and tough, and at the same time so malleable, that it can be rolled into sheets of the three-hundredth part of an inch in thickness; and that when wrought iron can be twisted, cold, into any shape without breaking, he may rest assured that it is as near pure iron as he may wish to have for the proper execution of his work.

It may not be out of place in this part of our treatise to give a few hints to the smith on the subject of fitting. It often becomes necessary, when fitting in intricate pieces, to apply the iron while it is red-hot, and if due precaution be not taken, the wood becomes charred and worthless; and in cases where there are glued joints, it may cause the loosening or breaking of these joints, and other material defects. All this may be overcome in the simplest way. No well-regulated smith's shop should be without a heat neutraliser, such as chalk. If chalk be well rubbed over the surface on which we intend applying hot iron, we can apply it almost with impunity. Plaster of Paris is a still more powerful neutraliser of heat, as it is freer from grit, and with this we can make a more perfect fit. A small quantity of the plaster mixed with water, and pressed into a manageable shape, will be ready for use in about two hours. We are quite

aware that chalk is frequently rubbed by the smith over the woodwork whereon he is about to fit his plates, but this is done in order that he may more distinctly observe where the plate takes its bearings and where it does not. This, of course, is an advantage; but if it were more generally known that chalk or plaster of Paris was a heat neutraliser, these substances would be more freely and more universally applied.

We have already pointed out the advantage of compassing the beds of the fore-carriage. It enables a carriage-maker to place his front wheels farther back than the straight bed will permit of, and it renders his work more compact in appearance; moreover, the closer the front and hind wheels are brought together, the better is the body supported, and the lighter it may be constructed. Another advantage is also supposed to be gained by this process, namely, that of lessening the draught of the vehicle on the common road. We say "supposed" advisedly, for there are as many opponents as advocates of the theory, neither are we in a position to speak authoritatively on the relative merits of the long and the short lock, under which heading this question has been largely discussed in the trade, for the facts of the case have never been thoroughly investigated.

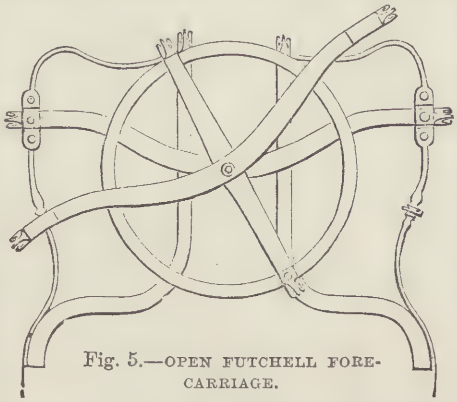


Fig. 5.—OPEN FUTCHELL FORE-CARRIAGE.

Much ingenuity has been displayed, and expense incurred by those who advocate the theory that to shorten the distance between the hind and front wheels is to lessen the draught, in the production of various inventions for bringing the hind and the front wheels of a four-wheeled vehicle closer together than the common lock will permit of. These inventions consist, for the most part, of patent wheel-plates with sliding centres, but we have no faith in any of them, inasmuch as a sliding centre cannot be so firm as a fixed one, and the peculiar action which their construction involves, no matter how each may differ from the other in detail, has the effect of throwing the front part of the body right off from its central bearings as the wheel locks round; moreover, we are far from satisfied that they fulfil the object for which they are intended.

We have frequently asked these inventors, "Have you ever tried whether or not your theory of the long and short lock is correct?" and have invariably obtained the same answer, "No." There are as many conflicting opinions on this subject now as there were ten or twenty years ago, and no efforts have been made to arrive at a satisfactory conclusion. About ten years ago, the question appeared to have assumed quite a popular character, and at least one coach-builder considered that the time had come to fully investigate it. It was suggested that a series of experiments should be tried, not with mere models, but that they should be carried out upon the high road with carriages themselves over given distances and gradients. According to this plan, proper indicators were to be attached, and the result registered mechanically, that would form a basis upon which some satisfactory conclusion could be worked out.

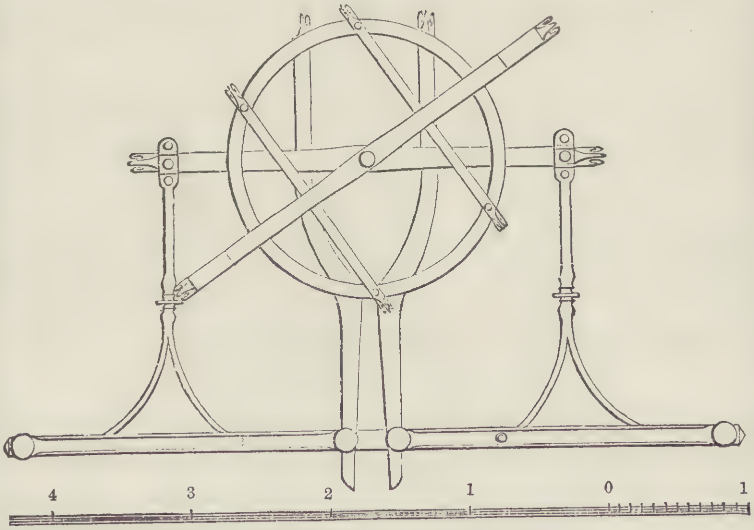


Fig. 6.—CLOSE FUTCHELL FORE-CARRIAGE.

But the objection to this proposition was, that it would be attended with a good deal of expense. It was proposed, however, to raise a five-shilling subscription, and that as soon as a sufficient sum, say £30, was obtained, or rather promised, a meeting should be convened and a committee formed, the duty of which should be to give due publicity to the undertaking, whereby general interest would be excited and the necessary funds realised.

So sanguine was the promoter of this scheme, that he flattered himself thousands would come forward willing to lend their aid in defraying the expense, and he actually proposed what was to be done with the surplus funds, after all the necessary instruments had been purchased, and all the various expenses of the undertaking incurred. Nevertheless, the proposition fell to the ground, and although one or two coach-builders may have partially satisfied themselves on this important subject by imperfect experiment, the subject is still left for decision practically in the hands of coachmen, whose supposed experience is largely accepted as evidence.

But while the decision is thus left in abeyance as to the desirability of throwing the front wheels farther back for the purpose of lessening the draught, Mr. Offord, of Wells Street, Oxford Street, and Brook Street, Grosvenor Square, has been exercising his ingenuity to throw the back wheels farther forward, and has produced a brougham that offers peculiar advantages in this respect. The hind wheel appears to be placed right across the door, but the facilities for ingress and egress are equal to those given in the ordinary brougham. We purpose giving in our next paper an illustration showing a carriage of this description.

This novel contrivance presents nothing singular in appearance, while a very little reflection will satisfy a practical thinker that the advantage sought after of lessening the draught of the carriage, must be obtained far more completely than by throwing the front wheel backward. The wheels to a vehicle are what the legs are to an animal; they are its locomotive power. The ordinary mode of construction of our four-wheeled carriages necessitates attaching a support or pump-handle at the back part of the body; this becomes the bearing for the hind wheels, which, for the most part, are placed *beyond the extremity* of the body. Did ever any one see an animal that had its hind legs placed beyond the extremity of its body? Surely the silent teachings of Nature must be worth something in such matters, and we can see in this plan of shortening the distance between the hind and front wheels some solid practical advantage.

But there is another question to be discussed in relation to draught. It is a common error that the springs of a carriage perform no other office than that of giving elasticity to the body and ease to the riders. It has been proved, however, by actual experiment carefully carried out, that they perform an important part in the economy of draught. This, however, we will discuss in our next paper.

INDIAN RUBBER.—III.

BY GEORGE GLADSTONE, F.C.S.

COMPOUNDS WITH PITCH AND TAR—CEMENTS—MASTICATION—PROPERTIES OF MASTICATED RUBBER—PURIFICATION—KNEADING—CUTTING INTO SHEETS AND THREADS—MAKING OF ROUND THREAD.

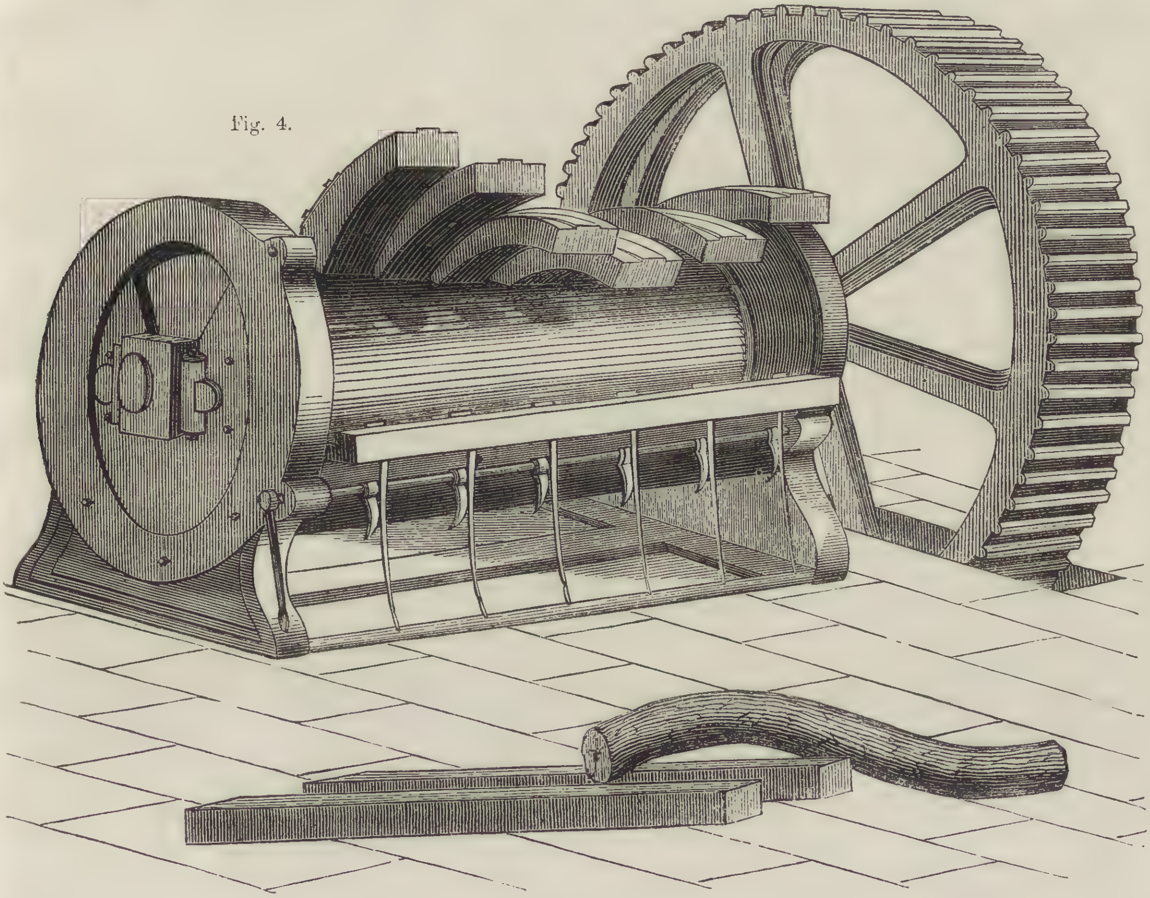
In addition to the applications of a solution of Indian rubber mentioned in the last article, there are others in which it may be used with advantage.

Thus a compound of it with pitch and tar possesses also very useful properties. It may be employed in making cordage; or for saturating canvas, or the felt or paper used under the sheathing of ships or roofing of houses; or as a substitute for the common pitch in preserving woodwork from the effects of wet. The product will be more elastic and durable, as well as less affected by the exposure to the weather, than either of the articles with which it is compounded. The Indian rubber must be first dissolved in naphtha, oil of turpentine, or other suitable solvent, and it is then ready to be mixed with the others. Tar will combine with it readily at an ordinary temperature; but the pitch must, of course, be melted sufficiently to become fluid, and must be maintained at such temperature until the mixture with the solution is complete. Either or both these articles may be used according to the purpose for which the compound is wanted.

A glue of a very adhesive character can also be made, in which Indian rubber forms an important ingredient. A pound of the rubber should be dissolved in four gallons of naphtha, and allowed to stand until it becomes about as thick as cream. To this about double the quantity, by weight, of shellac should be added, and the whole heated in an iron vessel and well stirred until the lac has thoroughly combined with it. It can then be poured out into shapes, and will solidify as it cools. When the glue is wanted for use, one of the cakes has only to be put into an iron pot and heated up to about 250° Fahrenheit, when it will commence to liquify. It should be applied with a brush to the surfaces of the wood which are intended to be united as quickly as possible, and then the pieces should be pressed together for a short time. As soon as the glue has thoroughly set the adhesion will be so perfect that the wood itself will break sooner than the composition will give way.

Another cement is prepared by heating the caoutchouc up to 398° Fahr., at which point it no longer dries on cooling (which it does when melted at any lower temperature). To a pound of this add half a pound of powdered slaked lime, and work them up together. The mixture will form a tenacious non-drying substance, very convenient in many scientific operations, as in temporarily closing glass vessels air or water-tight, which, at the same time, can be loosened with the greatest readiness whenever desired. If a permanent drying cement is wanted, it is only necessary to add half a pound of red lead to the above, and work up together all the three ingredients.

Fig. 4.



We must, however, take leave of the applications of Indian rubber by the aid of solvents, and consider how it can be utilised without their assistance. Only very small blocks or sheets could possibly be cut out of the irregular-shaped pieces received from abroad, and in doing this a great amount of waste was inevitably incurred, which, in so high-priced an article, became a very serious matter. Attention was therefore turned to the question of making use of these waste cuttings. The property which caoutchouc possesses of uniting together whenever two fresh cut and clean surfaces are brought into contact, cannot fail to have attracted the notice of every worker in the

article. Mr. Hancock tried to avail himself of this in his earliest experiments, and constructed a small hand-mill, consisting of a hollow drum of wood, in which a cylinder of the same material turned; the inner surface of the drum and the exterior of the revolving cylinder were armed with spikes and sharp-cutting edges. The labour of turning it was very great, even when operating on a charge of only two ounces; but it was found to produce the result intended. The shreds of Indian rubber were lacerated and torn in all directions; but the newly-exposed surfaces adhered as fast as they were laid open, and gradually united into one lump, homogeneous in the centre, the surface merely being perforated or indented by the teeth. The principle was thus established, and it only needed development and adaptation from time to time to the growing necessities of the trade.

Masticated rubber is the result of the process, of which the above were the first beginnings. It is not altogether so good as the article produced in Nature's laboratory; but, at all events, it is a remarkably good substitute for it, and has two great advantages:—(1st.) It can be freed from all the adulterations and impurities which the native Indians may choose to mix with it; and (2nd) it can be had in blocks of a size which it is almost impossible to make on the spot where the juice is gathered. The blocks of solid and pure rubber turned out by the machinery of one of the largest works, the masticator belonging to which is figured in Fig. 4 in the preceding page, are 6 feet in length, by 12 to 13 inches wide, and about 7 inches thick. Two of these, after compression, and one as taken out of the machine, are shown in the foreground.

The masticated rubber is more liable to atmospheric influences than the original article, which is probably due to the heat that is inevitably evolved during the process having produced a certain change in its substance. It is impossible to subject the rubber to the action of any machine like that which we have described, without causing a considerable amount of heat; and it was found by experiment that a lump thus produced indicated in its centre, when speedily cut open, about 280°, which is, of course, above the point where it begins to melt. But if the masticator is worked rapidly, and a still greater heat engendered, a distinct action is set up, and we no longer find the product to be a pure hydrocarbon; an oxidised body will result, and instead of yielding by analysis—carbon, 87·2; hydrogen, 12·8, we have now—carbon, 86·6; hydrogen, 11·3; oxygen, 2·1. But even suppose the mastication to have been managed more carefully, we shall get a product yielding carbon, 87·7; hydrogen, 12·3, instead of the first set of numbers given above, showing a loss of hydrogen and a comparative gain of carbon.

The demand for the masticated article was always equal to the supply, as new applications for it continually arose. It was cut into neat little blocks for the stationers, and into thin sheets and threads for various manufacturing purposes. For the latter it is very necessary that all the impurities should be perfectly got rid of, and so the rubber has to undergo a thorough purification before being worked up into the larger masses.

With this object the raw material is cut up into very small pieces or shreds, and agitated well in warm water. After the first washing it is spread out to dry on iron plates heated by steam, and turned over from time to time to separate any adhering dirt. It is again washed by being passed between rollers under water; and these processes are repeated as long as any dirt is found to be carried away by the water.

The purified rubber has then to be put into another machine to expel all the moisture and knead it into one mass. The kneading machine is usually made in the form of a cylinder placed horizontally, through which passes a shaft with two or three rows of projecting bars, which rotate against a series of fine chisel-shaped teeth. Sometimes more than one of these machines is adopted, the arrangement of the compressing and cutting instruments being varied, so that the greatest measure of effect may be attained in forcing out the moisture, and also the air, which may get included within the substance of the rubber. The expulsion of the water is materially aided by the heat evolved during the mastication, sufficient, indeed, to convert the water into steam, which escapes with violence. In the later steps of the process the revolving cylinder has often nothing more than a corrugated surface, which will hold with sufficient tenacity the roll of stuff submitted to its action.

The piece of masticated rubber is then taken out and put into a press, usually worked upon the hydraulic principle. In some factories it is compressed into long rectangular blocks, as shown in the drawing; in others it is pressed into the ordinary form of a cheese. The whole force of the press must not, however, be exerted at once, and the maximum force to be applied must be maintained until the rubber is quite cool, when it will retain its figure after the compressing force is withdrawn.

The blocks thus made are principally used for cutting into sheets and threads, in which forms Indian rubber is largely employed for manufacturing purposes. Any one who attempts for the first time to cut a piece in two will find it not so easy a matter, as the knife is sure to stick fast. This difficulty is obviated by directing a jet of water so that the cutting edge shall always be kept wet; and by the following mechanical arrangement sheets can be cut of any thickness that may be desired, and with the greatest regularity. The cutting machine is planned so that a straight steel blade is made to vibrate rapidly to and fro in a horizontal plane, while the block of rubber, clamped firmly between two iron bars, is slowly advanced against the blade by screw-work, like that of the slide-rest of a lathe. The knife is so fixed as to slant obliquely downwards in order that the sheet, which is cut from the lower side, may turn over as soon as cut and free itself from contact with the blade. The sheets, as originally cut, will naturally be limited to the size of the block; but two clean fresh-cut edges will unite so perfectly on being pressed together, that large sheets used to be thus made from small blocks, at a time when the masticators were not sufficiently powerful to work up large charges.

Many of the sheets were used for cutting either into narrow ribands or into thread; but as the native rubber is stronger than the masticated, plans have been devised for cutting a long riband out of the original bottles, which is afterwards reduced by another machine into thread.

According to one process, the bottom of a bottle is taken and flattened out into a circular disc of even thickness by being heated under pressure in an iron mould. The disc is then fixed to the end of a horizontal shaft, which revolves in the same way as a lathe, while a circular steel knife, which also revolves rapidly, is so adjusted as to pare off a continuous strip of even thickness from the surface of the disc. A little stream of water trickles down upon the spot where the knife comes into contact with the disc. By another arrangement of the machinery a similar riband can be cut from the circular portion of the bottle: this piece, being separated from the neck and bottom, is fitted upon a mandril of soft wood sufficiently large to keep the cylinder of rubber evenly distended. This is fitted upon the shaft of a lathe, while a circular stéel knife is attached to a second shaft parallel to the other at just such a distance as shall cut through the cylinder. The first-named shaft works into a fine screw, so that in the course of its rotation it advances just sufficiently to make the knife cut a continuous riband from one end of the cylinder to the other.

The ribands are afterwards subdivided into thread, by passing them between two series of circular knives mounted on rollers; the width between each knife-edge can be regulated at pleasure, according to the fineness of the thread which may be required, by varying the washers which separate the knives. These are usually made of brass in sets of different thicknesses. Each series of knives is screwed firmly together, and then, on the rollers being made to revolve, the riband is drawn between them and cut into as many threads as the width will allow. If the threads get broken during the subsequent manipulation, or if they are originally cut from short pieces and it is desired to lengthen them, they can be easily joined by cutting the two ends on a slant with a clean dry pair of scissors, and then pressing the two fresh cuts together between the finger and thumb. The warmth of these will be sufficient to make them adhere perfectly.

It is evident, from the character of the machinery above described, that the threads so manufactured must be rectangular; and those who have pulled a bit of elastic to pieces will often have observed that such was their form. The French have the credit of introducing the cylindrical thread, which is not produced by any cutting apparatus, but by one adapted to a totally different principle. It will be remembered that in the previous article bisulphide of carbon was mentioned as one of

those liquids in which caoutchouc is but sparingly soluble, while alcohol exercises no effect whatever in that direction, but rather the reverse. Advantage was taken of this, and a combination prepared, containing 95 per cent. of bisulphide of carbon and 5 per cent. of alcohol, which was found not to dissolve the substance, but only to reduce it to a pasty consistence. After twelve to fifteen hours' exposure to this compound the paste is ready for use; it is then put into a cylinder, the lower part of which is perforated with a series of circular holes, usually about one-twenty-fourth of an inch in diameter, and through these the pasty mass is forced by the pressure of the descending piston, while an endless web of velvet, which travels at an appropriate rate, receives upon its surface the semi-solid threads of rubber as they pass out of the holes, and carries them off to a proper receptacle, where they dry by evaporation of the highly volatile bisulphide of carbon before they have the opportunity of sticking together.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVIII.—ROMÉ DE L'ISLE.

BY JAMES GRANT.

JEAN LOUIS BAPTISTE ROMÉ DE L'ISLE, the celebrated French crystallographer, and the first who brought the study and science of mineralogy into prominence, was born in 1736, at Gray, a small town in the east of France, in Franche-Comte, or Haute Bourgogne, long an independent province, and only incorporated with France in 1678. At an early period of life he was appointed secretary to a corps of engineers, and in this capacity went to the French East Indies. The period of his first return is unknown, but in the year 1757 he was again on service in the East, and fought at the defence of Pondicherry, a town on the Coromandel coast of Hindostan, when it was besieged by the British forces under Colonel Coote in 1761. The garrison consisted of the regiments of Lorraine, La Marine, de Lally (of the Irish brigade), the volunteers of Bourbon, the battalion d'India, and other forces, and the defence was long and desperate, being conducted by Arthur, Count Lally, an Irishman in the service of Louis XV. The garrison became prisoners of war, and on this occasion plunder to the value of two millions sterling fell into the hands of the British.

In 1764, after three years of captivity, Romé de L'Isle and Count Lally about the same time returned to Paris, where the latter was arrested on certain pretended charges connected with the fall of Pondicherry, and notwithstanding his long and gallant services, was taken from the Bastille, and cruelly beheaded in the Place de Grève, with a gag in his mouth, to prevent him from addressing the people.

With the capture of Pondicherry the career of De L'Isle as a military engineer ended, and he applied himself to the study of natural science. In 1766 he published a "Letter to M. Bertrand on Fresh-water Polypes," in which he considered the polypus as a tube for the reception of an infinity of small isolated animals. Having commenced, along with Le Sage, the study of natural history, he directed his attention particularly to mineralogy, and his first work was a "Catalogue Raisonnée" of M. Davila's collection intended for sale; and this work appeared in 1767 in three volumes octavo, and by this he was led into an accurate examination of the forms of crystallised bodies, and to the construction of a system of crystallography.

His first essay on that subject was published in 1771, and contains 110 specimens of crystals; of these the great naturalist Linnæus knew but forty. The production of this work extended his fame among the learned. His correspondence was courted by Linnæus, and he was honoured with a seat in most of the academies of Europe.

His own countrymen were, however, the last to discover any merit in Romé de L'Isle, and from the circumstance of his having published eight explanatory catalogues of collections of minerals between 1767 and 1782, they were somewhat disposed to regard him more as a scientific drudge than as a learned philosopher.

In 1778 he published an explanation of Le Sage's theory of chemistry, and one year afterwards appeared his work entitled, "L'Action de Feu central, banni de la surface du Globe, et le soleil rétabli dans ses droits."

His first work, however, by which he will be long and honourably remembered, appeared in 1783 under the title of "Crystallographie; ou, Description des Formes propres de tous les Corps du Règne Minérale," in four volumes octavo.

The wonderful merits of De L'Isle in mineralogy are less generally acknowledged than they deserve, particularly in France, though recent mineralogists have been frequently astonished at the accuracy of the descriptions given by this author, even of such substances as were afterwards confounded with each other by Haüy in his "Primitive Form of Crystals," and others who have copied him.

The power of observation is displayed in every page in a very remarkable degree, joined with much good sense, close reasoning, and vast mineralogical knowledge. His forms of crystals, however, are frequently far from affording the pleasing effect of geometric perfection, which so charms the eye, in the diagrams that adorn the great work of Haüy. They evince, however, the hand of a master whose eye could grasp, and whose pencil could reproduce, the peculiar character of the individual crystals which he represents, and which is often preserved more correctly in those sketches than in better executed drawings.

In perusing the second edition of "Crystallographie," the student will always find a great deal of instruction, the result of more than twenty years' constant and well-directed exertion on the part of Romé de L'Isle; but even those who may be, perhaps, already proficient in that science, will find pleasure by discovering in his works that they have been anticipated in their descriptions. With perfect propriety it may be said that however ingenious the views of Haüy may have been in regard to the property of cleavage, he could never have succeeded in establishing them as a general system had he not possessed the observations and drawings of the ex-engineer of Pondicherry.

The latter met with all the opposition commonly incidental to new ideas, or to that degree of accuracy which is far beyond what had been customary before; but the prejudice had worn away when Haüy's system appeared, and won the plaudits due to its own merits and those of Romé de L'Isle. The former was always generous enough to acknowledge all he owed to the latter; he supplied the link in the chain which made his observations useful, by introducing general views in crystallography founded upon geometrical processes, and by giving to every substance determined to be a separate species a particular name.

Regardless of the two great points, which, according to Linnæus, like the thread of Ariadne, lead us through the maze of the variety of Nature—the systematic disposition and denomination of the species—Romé de L'Isle, in his paper entitled "Des Caractères Extérieures des Minéraux," has given principles for the determination of the latter, apart from chemical analysis, and these principles will stand every attack, and must ever remain one of the most valuable disquisitions proposed on the subject to the public; and these ought to be studied by all who wish information on a subject so important.

Romé de L'Isle was the first to raise mineralogy to the rank of a well-defined branch of natural history, in spite of the pretensions of chemists, who, even at that time, when the knowledge of this science was crude and imperfect, particularly so far as minerals were concerned, undervalued everything that was constant in minerals, and that they might fail to understand. In a great measure all this may account for the reason why the works and researches of Romé de L'Isle have been so neglected, and though amply used by Haüy and others, have never had that degree of influence to which their excellence entitled them.

Besides the works already enumerated, he published, in 1787, "Extérieures des Minéraux;" and in 1789, "Métrologie, ou Tables pour servir à l'Intelligence des Poids et des Mésures des Anciens, d'apres leur Rapport avec les Poids et les Mésures de la France."

Still his own countrymen ignored him.

According to the editors of "Rozier's Journal," in 1789, we find it stated that "M. Romé de L'Isle, whose name will last so long as science shall be cultivated, though honoured by foreigners, and associated with the most learned societies in Europe, has still been elected a member of *no* academy in France; nor has he any place. Places and pensions our own academicians have now contrived to banish away with the prodigality of courtiers; but (we hope) the public esteem will indemnify this valuable citizen for an injustice which the nation disavows. Academical

aristocracy is not less injurious to the republic of letters than patrician aristocracy to political constitutions."

But no honours awaited Romé de L'Isle in France, where the downward course of the Republic had begun.

His "Métrologie" contained a system of tables for understanding the weights and measures of the ancients, and in a particular manner for determining the value of Greek and Roman money, and the proportions they bear to the present weights of coin and money in France.

A work of this kind is very remote from the subjects about which our crystallographer was chiefly conversant; but his whole time was dedicated to labour, and he lost none of it in cringing among courtiers, or seeking by intrigue, cabal, or solicitation to gain place or pension, though age was creeping upon him.

It had been talked of at that time to have uniform systems of weights and measures in Europe. "If so," says the editor of "Rozier's Journal," with reference to the last work of Romé de L'Isle, "then imitate the measures of the ancients, as given there, either by adopting the geometrical foot, taken from the measurement of a degree of the meridian, or the pythic foot, taken from the length of a pendulum vibrating seconds, which still (1789) exists at Marseilles and Genoa, under the name *palin*, and we might substitute *stadium* for *mile*."

Some time before his death Romé de L'Isle was blind, and he died of dropsy, at Paris, in March, 1790, in the sixtieth year of his age.

CAPITAL AND LABOUR.—VIII.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

CO-OPERATION.

The struggle between the workman and employer is always active, and always will be actively carried on, as long as their present relations subsist. The cause for this permanent unsettlement has been already stated, but it bears repetition partly because of its importance, partly because it is rarely apprehended. It arises from the fact that both employer and workman are paid for their labour, both receiving wages; and because there can only be a very imperfect means for adjudicating what is the portion which each of the parties should receive, or if they differ, there is no effectual process by which the rival claims of both should be satisfied. It is true that the adjudication is easier in some cases than it is in others, but it is imperfect in all, and it is certain that the settlement of no trade dispute ever leaves both the parties in the arrangement convinced that the decision or compromise has been thoroughly equitable, and therefore incapable of being challenged.

The rivalry, then, between the employer and the workman can never come to an end as long as the relations of employer and workman subsist, though under certain circumstances and in certain callings it can be greatly modified. It is only when the functions of capitalist (in the popular sense of the word) and labourer are united in the same person, that those expedients by which the workman attempts to obtain better terms for his labour from his employer will be understood and adjusted. This change may occur either by the workman finding his own customer —*i.e.*, being in business for himself— or by his uniting in a trade partnership with other workmen, with the distinct purpose of using his own capital as well as his own labour under such an association. The latter form of action is called co-operation. This word is convenient, because its significance is vague and general.

Certain callings are, it appears, peculiarly capable of being carried out on a small scale. One of these is agriculture. There is abundant evidence to the fact that all kinds of agriculture may be very advantageously carried out under a system of small holdings, and that certain agricultural processes can be carried on in no other way to advantage. Such, for instance, are the successful cultivation of the vine, and other fruits, the production of silk and similar operations which need incessant and minute attention. It is clear that dairy-farming is most advantageously practised on a small scale. Similarly, there are other branches of industry which have the same characteristics. Certain kinds of mining are most likely to be successful when the miner has a notable share in the returns of the mine. So again, some of the nicest work of the gunsmith is done by operatives who work on their own account.

If the workman is directly interested in the success of his work, we may anticipate that he will be more than ordinarily active in the industry which engages his attention. If the business be one of dealing only, the participation in business profits makes the individual more brisk, more pushing, and more cautious. If it be one of production, he is attentive to little economies, the saving in which, though it seems small, amounts, when the number of operations are many, to a considerable quantity on the side of business profit. So thoroughly is this understood by men of business, that it is a very common thing for merchants to pay their agents by a certain share in the nett profits of the calling in which they are employed. It is a growing custom with manufacturers, owners of collieries and the like, to admit their workmen to a share in the profits, and therefore to communicate to them full information as to the details of their business. In such cases, the workman, though he be not in law a partner with his employer, is in fact occupying such a position, and such associations of employers and workmen are frequently called co-operative undertakings, since the arrangement partakes of the nature of co-operation, as the word is popularly understood.

They are not, however, exactly the same. In the co-operative system, the workman finds all that the capitalist supplies, and contributes his manual labour also. Of course his object in doing this is to appropriate that to himself which the employer generally secures under the name of profits. He may attempt to obtain this advantage, either in his character of a consumer, or in that of a producer. He may seek to bring himself, as a purchaser of the goods which he requires for his subsistence or comfort, nearer to other producers by seeking to get rid of the middleman or dealer. This, under the system of what are called co-operative shops, is the most familiar example of such joint or co-operative action in this country. Rightly or wrongly, consumers have thought on certain occasions that the profit of the retail dealer is excessive, in proportion to the service which he renders, and that he could on many grounds be dispensed with, to the convenience or advantage of those who buy goods. Similarly it is asserted, with more or less justice, that the retail trader is tempted to various kinds of fraud, and there is evidence that the fraud is frequently practised. It is also said that a system of co-operative shops is not only an advantage to the purchaser, but indirectly a great advantage to the producer. If it be the case that in such shops the purchaser makes a saving of expense to the extent of 10 per cent. on the cost of that which he buys, it is plain that he has 10 per cent. on his income more to spend; and as in accordance with what has been stated above, the stimulus to labour is the demand of those who require the objects on which industry is exercised, the saving of 10 per cent. in the cost of supplying one's wants, is an addition of 10 per cent. to the means which the consumer has for calling the producer into activity.

This kind of co-operation, however, though it may give the purchaser a larger command over the necessaries and conveniences of life, and may supply him with better as well as with cheaper goods, is not the most important kind of co-operation. Much more significant is the co-operation of production—*i.e.*, the union of workmen together for the purpose of supplying the public with goods. Such a form of co-operation has been adopted with great success, and is growing in Northern Germany, a system having been established in that country, under which banks are formed to receive the savings of workmen, with a view to such savings being employed for purposes of business. Undertakings of a similar kind have been entered on in this country, particularly in the Lancashire district, where there are cotton and other mills, the owners of which are the artisans who work in the building.

In all these associations, the first necessity, and yet very often the most difficult requisite to secure, is the discipline and obedience of those who are employed and are the owners of the undertaking. A great manufactory is like a regiment of soldiers, the effectiveness of which is due to its drill and deference to lawful and necessary orders. Such an establishment needs a manager, whose commands must be cheerfully and implicitly obeyed. It is not always easy to find a competent manager, and it is in the same manner not always easy to find docile workmen. It is stated, and perhaps with some justice, that the characteristic of docility is not general among English workmen, and that the absence of this quality

is a powerful hindrance to the development of the co-operative principle in this country. But there is no doubt that any future improvement in the condition of the English artisan or workman depends mainly on the success with which co-operation, with its economies, and indirectly, its high moral training, can be adopted.

It is an error to suppose that co-operation is available only for manufacturing operations. It is equally susceptible of application to agriculture. In point of fact, it is the only means by which a system of small tenancies, which most observers have admitted to be a great boon to the agricultural population, may, in addition to their own special merits as a form of industry peculiarly fitted for certain operations, successfully rival large farming. The large farmer is able to economise labour by the purchase and use of costly machines. Now such economies are out of the question in the case of small farmers, if they are to purchase the machine as individuals. But there is no reason why they should not unite to purchase them, for just as in great joint-stock undertakings the aggregate of small shareholders represents much greater wealth than the subscription of the richest individual, so a combination of small farmers could readily purchase the most perfect machinery, and so combine all the advantages of their own tenure with those which are admitted to belong to a system of large holdings.

PHOTOGRAPHY.—XII.

By J. C. Leake.

COPYING MAPS AND DRAWINGS—FORM OF LENS—ADJUSTMENT OF CAMERA AND STAND—COPYING OIL PAINTINGS.

The reproduction of maps, plans, and drawings is one of the most useful applications of photography. By means of the camera, copies of drawings or manuscripts may be produced in a fraction of the time which would be needed when they are copied by any of the ordinary processes of engraving; while their accuracy is such as to be beyond suspicion. For these reasons as well as others, it is of importance to all engaged in the mechanical arts, especially such as building and engineering, that they should be able by means of the camera to reproduce working drawings or plans, which, by the aid of this art, they may do in infinitely less time than would be required to make an ordinary tracing. In order, however, to make a photograph of a map, or any drawing, some care is necessary and certain precautions must be observed, as it is only when properly used that photography is capable of rendering good and trustworthy copies. We will, therefore, in this paper proceed to give such instructions as may enable the operator to ensure perfect accuracy in his work.

The first matter requiring attention is that of the lens employed, as although common landscape lenses or the ordinary portrait combinations may give good definition and perfect sharpness of line when used for ordinary purposes, they mostly distort the image more or less. In copying drawings or maps, of course, this cannot be tolerated. Perfect accuracy is an absolute necessity, especially where a map or drawing has to be copied in several portions and afterwards joined. It is therefore usual to employ a lens constructed specially for the purpose, in which flatness of field, perfect definition, and freedom from distortion are combined to the greatest degree possible. There are various instruments now produced by both English and foreign makers, in which these qualities are combined in a remarkable degree, and in the purchase of which the operator cannot do better than be guided by some respectable optician or photographer.

The camera also will most probably require some alteration or re-arrangement in order to adapt it to the focus of the copying lens, which will be found to be very much longer than usual. If a special camera be not employed, the body of the ordinary one may be lengthened by fitting a cone of wood, which may support the lens; or by the insertion of an extra sliding box arranged in the centre between the front and back of the original camera. Where, however, much work of this description is required, it is better at once to procure a properly made instrument with a bellows body, and rack-work for adjustment, as it is well nigh impossible to produce really first-rate and accurate copies without.

The stand should also be one of extreme strength and steadiness, capable of being easily moved and adjusted, and of such weight as not to be liable to the slightest vibration, which would, of course, render the lines of the drawing in a blurred and indistinct manner.

A stout board well clamped, and perfectly flat, of sufficient size to support the picture or drawing to be copied, must also be provided, and this must be fixed so as to ensure perfect steadiness, either upon a stand, or to a wall in some convenient and well-lighted situation.

The lighting of the surface to be copied is a matter of considerable importance, as upon this will depend much of the perfection of the copy. If the light be allowed to fall obliquely upon the surface, very much of the texture of the paper will be reproduced; often to the destruction, or at any rate partial obliteration, of the finer lines. The best method is to allow the light to fall upon the drawing from the front, over the camera, and, of course, every part must be equally illuminated. The drawing must be placed perfectly flat, avoiding all creases or folds, a most important point, as these will be reproduced in the copy, and present uneven patches of light and shade. It is an advantage to copy drawings before their removal from the board upon which they have been stretched, as they will then be perfectly flat. Loose drawings may be fastened with drawing pins, but in all cases the greatest possible flatness must be secured.

The camera may now be brought into position, and should be placed exactly in front of the drawing and parallel with it. The size will, of course, be regulated by the distance of the camera from the drawing, and the focal length of the lens; and may be easily adjusted by moving the camera backward or forward as required. The exact size of the reproduction may be readily determined by experiment; but if the focal length of the lens is known, a rough adjustment of the camera may be made before commencing the work. Thus, if it be required to copy a picture the same size as the original with a lens of six inches focus, the lens will require to be placed at a distance of twelve inches from the drawing; and the plate will be twelve inches behind the lens—in fact, the lens will be mid-way between the object to be copied and the plate which receives the impression. In all cases it should be remembered that the size of the picture depends not upon the diameter of the lens, but upon its focal length. Another rule which is important is this—that a lens will not copy a larger picture than it will take. Thus a lens which will cover a plate, and take a sharp picture of three inches in diameter, may be used for copying, or enlarging a picture of that size, but not larger. It will enlarge a picture of three inches to any size, but it will not copy one of six inches to the same size, without strain and risk of distortion.

It is of extreme importance that the camera should be placed exactly parallel with the drawing, in order to avoid distortion. To ensure this the following plan may be adopted:—A square of fine lines should be drawn upon the copying-board, so distinctly as to be readily seen upon the camera-screen of ground glass. Upon the ground glass should be drawn with a pencil another square. When these lines are quite coincident the camera will be at exact right angles with the board. This will be a ready method of determining a most important point, and will save much trouble in measuring.

The proper adjustments having been made, the plate may be prepared in the usual way. The collodion employed should be one giving a rather dense image and a thick creamy film. When the plates are large the collodion should contain a full proportion of alcohol, which will materially facilitate the production of an even coating, a matter of some importance in this case. Although a newly-iodised collodion is not to be recommended, we should advise that old samples should be avoided, as they not only work very much more slowly—an important point when copying with lenses of long focus—but it is often difficult to obtain sufficient intensity. The plates should be very carefully drained, and a slip of blotting-paper inserted in the camera-slide upon which the plate may rest. This will absorb the superfluous solution and prevent stains. When the weather is very hot it is a good plan to provide several thicknesses of blotting-paper of the size of the plate, and having soaked them in cold water—if iced it will be all the better—to place them at the back of the plate. This will serve to keep the plate cool,

and, by preventing the rapid evaporation of the solution, moist, during very long exposures. The great difficulty during long exposures is to keep the plate moist, and if it once becomes dry stains and patches invariably occur. If the above precautions are taken, however, this will but rarely be the case. The nitrate bath should be of full strength and in the best possible order, kept quite clean and free from dust or floating particles of collodion, which would, of course, cause spots and holes in the film.

The exposure of the plate should be continued long enough to ensure a tolerably rapid development of the image; as if the developer be kept upon the plate too long, there will be a danger of fogging, and subsequent obliteration of the finer lines. The best developer is one of sulphate of iron, which should not be too strong, say from ten to fifteen grains to the ounce, and it should contain full proportions of acetic acid and alcohol. As soon as the image is visible, and before the lines, which will appear white, are in the least degree clouded, the action should be stopped by plentiful washing. It is but seldom that sufficient density of deposit is obtained by this operation alone, and consequently a subsequent process must be employed.

A certain amount of density may be obtained by the usual process with pyrogallic acid and silver applied before fixing; but this must not be carried very far, or some of the fine lines may become obliterated. When, therefore, a moderate density has thus been obtained, it will be found better to fix the image with the ordinary cyanide of potassium solution. Any amount of density may then be obtained as follows:—Flood the plate with an aqueous solution of iodine, made by dissolving together five grains of pure iodine and two of iodide of potassium in one ounce of water. After a minute's treatment with this solution wash the plate well, and proceed to re-develop with the ordinary pyrogallic acid solution, to which add a small quantity of nitrate of silver. If carefully performed, this method will be found of vast service in promoting intensity of the image, without the slightest danger of destroying the fineness and evenness of the lines.

Unless a very open and porous collodion be employed, there will be danger of a splitting up of the film during the drying. To obviate this a weak solution of gum arabic, carefully filtered through muslin or flannel, should be poured over the film when wet. This will dry with the film into a kind of varnish, and prevent accidents of this description.

By the method above described, drawings, maps, engravings, or manuscripts may be easily copied; but when copies of oil paintings or coloured subjects are required, some little modification may be necessary. The copying of oil paintings is one of the most difficult branches of the photographic art; and except in rare instances the reproductions are scarcely to be pronounced satisfactory. This arises partially from the non-actinic quality of the colours employed, and partly from the glossy and uneven surface of the painted canvas. In most cases it will be found better to copy oil paintings in the sun, taking care to avoid all reflections from the surface. A highly bromised collodion should be employed, and as large an aperture of the lens as may be consistent with tolerable sharpness of the image. A rather strong iron solution may be employed for development, and care must be taken not to make the negative too dense.

It very often happens that oil paintings may be copied very much more perfectly while their surface is wet, as the colours appear more transparent, and fewer of the cracks or defects are visible. We have therefore employed a solution of pure glycerine for application to the surface, and have found it answer perfectly. Equal proportions of pure glycerine and water are to be mixed, and applied with a soft sponge, in just sufficient quantity to keep the surface of the painting damp during the exposure of the plate. The glycerine must afterwards be removed, and the painting cleaned with clean cold water.

In conclusion, we would observe that all copying requires the utmost care. The plates must be most perfectly cleaned, the chemicals must be in the best possible order, and, above all, it is of no use whatever to attempt this sort of work unless the light be good. Attention to these points will ensure success, which cannot be attained without it; but as this is all that is absolutely necessary, there will be no one who is earnest in his work that cannot command it.

TECHNICAL DRAWING.—LXXXV.

DRAWING FOR CABINET-MAKERS.

OF THE METHOD OF COLOURING DRAWINGS, AND OF WATER-COLOURS GENERALLY.

It has already been said that drawings of furniture, etc., are usually executed in water-colours, and it is therefore deemed necessary to give in this place some instructions on the subject, together with a brief account of the colours generally used.

Whatever has been said in the previous lessons, by way of impressing on the student care, neatness, and attention, must be repeated here. Nothing can be more objectionable than a coarse, careless water-colour drawing of furniture. Rough sketching is no doubt adapted for the delineation of some effects seen in landscapes, where the foliage of trees, the mountainous country scenery, the ever varying effects of sky and water, are all at variance with formal treatment, and demand the bold and free pencil of the painter who can enter into the spirit of the scene, and by, as it were, magic touches, convey the impression to others; but beginners often unfortunately fall into the idea, that to draw roughly and carelessly is to draw artistically. There cannot be a greater mistake; the roughness seen in the works of the greatest painters is the result of power; they do not paint roughly because they want to hide bad drawing, but because they are so well acquainted with the exact lines on which the true form depends, that they can by a few touches indicate it better than one less educated could by the most laboured work. But the pictures of our best painters show how carefully and how conscientiously they studied every line in their earlier periods, and how gradually they arrived at that freedom which so enchains our minds when looking at their works.

But in the class of art connected with the present subject, the beauty of the subject is dependent on correct drawing, and neat and accurate work. The colour and general rendering must be *artistic;* but this term means, done *according to the rules of art,* not that the *drawing* is to be *careless* and the *colouring sloppy.*

The method of mixing and applying water-colours has been given in THE TECHNICAL EDUCATOR, Vol. I., pages 31 and 57, and the following lesson is given in continuation of these.

In order to obtain the proper harmony of colour it is necessary that all the primaries should be present, either pure or mixed, in proper quantities. Thus in a design, if we have painted one part pure red, we must harmonise it by painting the other parts either in proper proportions of blue and yellow, or in green, which is a mixture of blue and yellow, neither of which exists in red.

Again, if we introduce yellow, we must follow with blue and red, or with purple, which is a mixture of blue and red, neither of which exists in the yellow.

Further, if our primary be blue, we must harmonise it with red or yellow, or with orange, a mixture of the two, neither of which exists in the blue.

The secondary colours are therefore said to be *complementary* to those primaries which do not enter into their composition. Thus orange is complementary to blue, and blue, *vice versa,* is complementary to orange.

Purple is complementary to yellow, and yellow to purple.

Green is complementary to red, and red to green.

The most beautiful effect of the merging of the colours into each other is seen in the rainbow:—Red, orange, yellow, green, blue, indigo, violet.

From the above it will be seen that when the red meets the yellow rays, the secondary colour, orange, is produced. The yellow and blue meeting, produce green. The blue and red give violet or purple, and the violet mixing with the blue produce indigo, which is a deep blue with a tinge of red in it.

When two secondary colours are mixed together they form a tertiary (or third) colour. Thus orange and green produce citrine.

Now it will be remembered that orange is composed of yellow and red, and that green is made up of yellow and blue, and therefore to harmonise with citrine we require a secondary colour, which has *no yellow* in it. This colour then must be *purple,* which is made up of blue and red only.

Purple (secondary) and green (secondary) produce the *tertiary olive,* and as purple is made up of blue and red, and green

is composed of blue and yellow, the colour to harmonise with blue is orange, which contains no blue at all.

Orange and purple produce the tertiary colour russet; and as orange is composed of yellow and red, and purple is composed of blue and red, green will harmonise with it because it contains no red.

The following are the colours mostly found in colour-boxes:—Prussian blue, sepia, burnt sienna, yellow ochre, vermilion, emerald green, lake (crimson or scarlet), Vandyke brown, gamboge, light red, Indian ink.

Prussian blue is a very fine deep colour, which works very smoothly. It is used not only by itself, but it mixes well with other colours.

Prussian blue, mixed with lake, makes a beautiful rich purple; more lake added, and the colour thinned, will produce violet.

Prussian blue, mixed with various quantities of gamboge, produces a beautiful bright green, used in colouring damask, or in shading emerald green. If more gamboge be added, it will become yellow-green, or with more blue, will become blue-green.

In mixing a green by night, it must be remembered that the light from gas or candles is not, like daylight, made up of red, blue, and yellow, but is altogether a *yellow* light. This will cause the green to look more yellow than it really is, and the green by daylight will thus appear a *blue* green. This must be guarded against by making the green mixed at night look more yellow than it is desired it should appear by day.

Indigo is a dark blue found in most colour-boxes. A colour very much like it can be made by the mixing of a little black and lake with the Prussian blue. Indigo is used for shading Prussian or other blues.

There are several other blues used in colouring drapery, the two principal of which are ultramarine and cobalt. These are, however, more expensive than the other colours, but if not in the box, they may be purchased separately. In using them, the colour must be stirred up at every brushful, as they are heavier than the Prussian blue, and separating from the water, sink to the bottom; a brushful of the mixture taken from the top is thus different from one taken from the bottom.

Ultramarine and *cobalt* are much used in designs. They may be mixed with white and lake, to produce the different shades of lilac and lavender, etc.

Sepia is a good dark-brown colour, much used for shading others, as it washes and tints off in a very suitable manner.

In commencing to paint in water-colours, the study should be begun by working for some time in sepia only. This style is called painting in *monochrome*, or *one* colour.

Vandyke brown and *burnt umber* are two very useful browns, not so dark as sepia. Both of these may be rendered warmer in tone by mixing lake with them.

Burnt sienna is a bright red-brown, and is very transparent. It is useful in shading gold or any yellow colours; or when a mixture of Vandyke brown and crimson lake has been washed over a surface, an additional tint of burnt sienna improves the colour meant to represent mahogany.

Emerald green is a bright colour, which is principally used in decorative painting, or in drapery, where it forms a good body to be glazed over by another green, for it is too cold a colour to be much used by itself. Special care is required in using this colour to keep it well mixed, as it is very heavy, and constantly sinks to the bottom. Putting the brush between the lips is always a bad habit, but it is especially dangerous when using emerald green, which is very poisonous.

Lake is a beautiful red colour. There are two shades, crimson and scarlet lake. The crimson is red, with a blue tinge, and the scarlet is red with a yellow tinge. Both these wash over the paper very smoothly, and are constantly used.

Vermilion is a very bright scarlet. It is very heavy, and thus separates from the water, or any colour with which it may be mixed, requiring to be stirred up as each brushful is taken. It is much used in ornamental painting, and may be shaded with lake.

Light red is not so bright a colour as vermilion, but is still very useful. It may be shaded with Vandyke brown or burnt umber.

Gamboge is a clear, bright yellow, which mixes very well with any other colour. It is very transparent, and lies evenly when spread thinly. Its use in mixing with blue to form green has already been mentioned. Indian yellow is much like gamboge, but much darker.

Yellow ochre is heavier than gamboge, and is neither so bright nor so transparent. It is used for colouring the lighter kinds of wood, and may be shaded with Vandyke brown, burnt umber, or sepia.

Indian ink is a full black. It is sold in sticks or large cakes. Should it have rather a brown tinge, it may be improved by being mixed with a small quantity of Prussian blue or indigo.

Several other colours may be found in boxes variously fitted. A little practice will soon enable the student to use them according to their different qualities.

FISH CULTURE.—XIV.

By Greville Fennell.

HISTORY OF THE OYSTER FISHERY AT THE ISLE OF RÉ—MODE OF CULTIVATION EMPLOYED—OYSTER FISHERY IN CONTINENTAL SALT-WATER LAKES—LUCRINE LAKE—FUSARO—AMERICAN OYSTER FISHERY.

The Isle of Ré, off the shore of the Lower Charente (near La Rochelle), in the Bay of Biscay, used to be taken by most oyster-culturists as the model ground for the breeding of this mollusk; and as its history involves nearly all the practical portion of the pursuit, we give it from various reliable sources, amongst which are Francis Francis, F. Buckland, Cholmondeley Pennell, Bertram, *Chambers' Journal*, etc., supplementing such information with facts which have reached us since the appearance of such publications.

It would seem that at one time the oysters grew naturally on the submerged stones and rocks which skirt the island of Ré, and that a quarter of a century ago they were tolerably plentiful; but when steamboats were introduced, and the other resources of quick travel came to be developed, oysters began to be more largely consumed, and the beds, in consequence, were spoliated faster than Nature could supply them—a condition which lasted a long time, since for ten years or so the only oysters that could be obtained on Ré were those grown by the salt-makers for their own use, which, however, were of excellent flavour.

About fourteen years ago, in March, 1858, the present era of oyster cultivation was begun; it was inaugurated by an old soldier, named Bœuf, a chevalier of the Legion of Honour, who, in 1867, followed the business of a stone-mason on the island. It is thought by some of the islanders that M. Bœuf must have acquired his knowledge of oyster-culture by accident. He gives out himself that he had a theory of an oyster-garden twenty years before he began his present farm. His ideas on the subject, he says, were taken from Nature; and he tried oyster-culture privately for some years before he applied for a concession of public ground. At first he laid out a very small parc—it was only twenty yards square—in a style a working mason might be expected to do, the wall being composed of sea-stones. The plan he adopted to stock his first parc was to gather together all the stones he could find on the natural beds upon which any oysters had fastened, and these he laid down within his enclosure, in the hope that they would yield spat in the warm months. He was not disappointed, for in less than a year he found that he was possessed of handsome crops of young oysters. He went on selling his produce and extending his ground. Thus, in the course of a season or two, he found that he had hit on an easy way of supplementing his income; and his success, the news of which soon spread far and wide, became so catching, that many of those residing on the island, particularly at Rivedoux, where Bœuf lives, began to cultivate oysters on their own account, or, at any rate, to take an interest in the business of those who did. In fact, the moment it came to be generally known that by growing oysters—and that oysters could be grown just like potatoes, Bœuf had demonstrated—good hard money could be obtained, there began an excitement on the subject of their culture.

All this, indeed, has suffered a sad reverse; but the foregoing facts are given as cautionary, being founded upon practical experience, which will stand its ground under average conditions and circumstances. Mr. Cholmondeley Pennell, at the time Inspector of Oyster Fisheries, visited the Île de Ré since the date to which we allude, and we thus summarise his report of the year 1868.

Île de Ré is, perhaps, the most celebrated of all the centres of modern French oyster-culture. The foreshores consist principally of mud, over a sandy subsoil, the line of the shore near high-water mark being, in many places, thickly strewn with a white argillaceous limestone belonging to the Oolitic group, and closely allied in structure to the lithographic stone of Solenhofen. The number of acres of these foreshores under cultivation as breeding parcs reached, in 1865, the extent of 400 acres, embracing 4,022 concessions granted since the beginning of 1857. Only 54 concessions have, however, been granted since; the numbers granted during the last five years being respectively 498, 298, 72, 3, and 54.

There are two principal differences between the method of oyster cultivation pursued at the Île de Ré and that described at most other places—the substitution of the stones for tiles as artificial collectors; and the placing of these collectors in excavations, in lieu of flush with the surrounding shore.

Fig. 30.—PILLARS WITH CORDS ATTACHED IN LAKE FUSARO.

The favourite size of these excavations is about 40 yards long by 20 broad, the soil being removed to the depth of one and a half to two feet. Both the walls and collectors in these excavated parcs are formed of the loose surface-stones—comparatively few tiles being used—and the bottoms are loosely paved with the same materials, of a smaller size.

The stones used as collectors average in size from one-fourth to three-fourths of a foot in diameter, and are arranged usually in rows or lines from one to one and a half feet high, and three to four feet wide. A parc of 20 yards by 40 would usually contain four or five of such rows of collectors, the walls themselves also serving the same purposes. In other parcs which are constructed flush with the foreshore, the stones are merely scattered irregularly over the surfaces.

The parcs are to a considerable extent situated below watermark of ordinary neap-tides, and are uncovered about five out of every fourteen days.

Fig. 31.—ARTIFICIAL OYSTER-BANK IN LAKE FUSARO.

The parcs at the Île de Ré were originally stocked entirely from the spat naturally brought into them by the tide; and both the inspector and commissary assured Mr. Pennell positively that the nearest oyster-beds of any sort were about 26 miles distant; and they conclude that the spat came from thence. Since the commencement of the system, in 1837, they have had good spats on the Île de Ré every year until 1862 inclusive, and since that there has been an almost complete failure. The condition of the parcs examined by Mr. Pennell fully corroborated previous suggestions that the whole of the industry was in danger of being destroyed by mud. Of the number of concessions already mentioned, 800 have been actually returned on the hands of Government, about 1,000 have been entirely abandoned, and a considerable portion of the remainder, it is to be feared, are practically valueless for collecting purposes. The excavated character of many of the parcs at the Île de Ré affords additional facilities for the accumulation of mud, which is thus protected, as it were, from the natural cleansing action of the tide. The proper time for the cleaning of the parcs and collectors is in April, May, and the beginning of June, so as to be ready for the spat, which, in the Île de Ré, usually falls towards the end of June or July. During the cleansing process the whole of the mud from the bottom, sides, and collectors should be carefully removed, and old collectors replaced by fresh ones; but this season a large proportion of the parcs have not been cleared at all, and but few have been stocked with new collectors. Only a small stock of breeding oysters now remain in some of the parcs nearest the sea, which here, as elsewhere, were regarded by the oyster-farmers as being by far the best for collecting purposes.

The young oysters are usually removed from the stones at one year old. The cause assigned by the officers for the recent failures was the improvidence of the concessionaires in selling off all their stock as soon as it was marketable, and leaving none from which to replenish the beds. Some concessions for fattening-pits have also been made at the Île de Ré, which have succeeded perfectly, both as regards the fattening and greening of the oysters laid down in them.

Dr. Bree says that no oysters, except those known as the Colchester or Pyfleet, will breed at all on our coasts. Notwithstanding the number of all kinds — Whitstable, North Country, Jersey, Welsh, Scotch, or Irish—that are laid down on our sea-beds, they never produce spawn. But if spat is brought from the above localities and laid down at Colchester, it will grow and thrive like the others.

The best oysters we get are natives, as the oysters of Whitstable, Milton, and Colchester chiefly are denominated. The small oysters, called in the trade "spat," are collected all round the coast, and deposited in the oyster-beds in localities most favourable to its development, where the greatest care is taken of the beds, star-fish and other vermin destructive to the oyster being carefully kept away from them, until the fish are fit for sale, when the oysters are dredged up, and any spat which may be adhering to them is removed and returned to the water. Vast quantities of oysters were brought from Jersey, where the oyster-beds were unusually large and fertile. The coarsest and worst oysters we obtain are the Channel and deep-sea oysters.

On many parts of the Continent, and particularly in Italy,

large salt-water lakes have been made, or are utilised, for the purposes of pisciculture. These works are, for the most part, the remains and the result of ancient industry. The singular lagune at Comacchio, on the Adriatic, is a peculiar instance of what art can do to assist nature in this respect. Originally the spot was a marsh, intersected by rivulets; at the outlet of these rivulets small islands, half submerged, lay close upon the coast. These rivulets were collected into a canal, the shallow pools made into one large lagune, the islands connected and raised, by means of wickerwork, etc., which made a labyrinth, at every outlet of which certain traps were set. The waters of the canal were turned into this lagune. The fish from the sea enter from the traps into the brackish water to spawn, but cannot return; and vast quantities of eels, mullets, and other fish are thus captured, a large stock always being kept up in the lagune.

of every fish or marine creature that can take it, whilst vast numbers perish from other circumstances; and were it not from the fact that each female oyster is said to give forth yearly from one to two millions of young, the stock, under the calls that are made upon it by man, must rapidly diminish.

When they wish to obtain oysters at Lake Fusaro, they either break them off the stones with hooks, or pull up the stakes or fagots, and detach such as they require with their hands.

"Dr. Kemmerer, of Ré, covers a number of tiles with a coating of a kind of mastic, brittle enough to enable him to detach the small oysters from it. When this coating is well covered with seed, he gets it off all in one piece, which he carries to the place where the seed is to grow. The same tile he coats a second time, and so on as long as the seed will deposit upon it.

GENERAL VIEW OF THE OYSTER PARCS IN LAKE FUSARO.

The Lucrine lake is another specimen of what can be done with oysters; but the salt lake of Fusaro is a more singular instance still. This lake, which is situated between the Lucrine lake, the ruins of Cumæ, and the point of Missene, was originally an extinct volcano, and at times, even now, the sulphurous exhalations penetrate the waters. About forty years ago the entire stock of oysters in the lake was killed from this cause, and the lake had to be re-stocked. The bottom is muddy, and is dotted over with large stones or fragments of rocks, to which the oysters may attach themselves; and round about these stones large stakes, which project above the water, are stuck into the soil—not so tightly, however, but that they can be withdrawn. From these stakes to others extend lines or cords, and from these cords, at intervals, are suspended fagots, to and within which the spawn of the oyster, when first hatched, can attach and ensconce itself until safe from any outward danger (Fig. 30). The use of these fagots and stakes is important, as when the young of the oyster is first hatched, it scatters in all directions, until it finds something to which it can safely attach itself. Meantime it is the prey

In short, wherever the violence of the currents and the stability of the bottom do not present irresistible obstacles, the cultivation of oysters has become a lucrative business."—*Galignani.*

The natural oyster fisheries of Cancale, once the most important in France, are, says Mr. Cholmondeley Pennell, still declining. They had risen to great importance by being left alone during the war between France and England in 1800 to 1815. In some places they had accumulated to a depth of more than a yard, and the annual catch immediately quadrupled and went on steadily increasing until 1847, when its maximum 71,000,000 of oysters was reached. The stock was thought inexhaustible, dredgers increased, and the natural consequence, its entire depletion, took place. At Granville the same results have followed from like causes. There are no artificial breeding-parks at either place.

Mr. Pennell considers the French principle of dividing the coast into districts, for the purposes of oyster-fishing, to be an excellent one, as it aims at giving each man in the district an interest in the prosperity of the fisheries, and also prevents a sudden descent of great numbers of men from different parts,

who would in a few weeks, or even days, indiscriminately clear out the oysters upon any bed where there might happen to be a good fall of spat, thus not only impoverishing the fishery, but also depriving the local dredgerman of the advantage which they might fairly expect to reap from what is after all often the result of their own labour. The principle, therefore, is excellent; it is an attempt at an approximation to the co-operative system; but, practically, the districts are so large, and the interests of each person consequently so small, that it fails in its most important object.

The American oyster industry (Chesapeake) is enormous. "It is impossible," says Genio C. Scott, "to arrive at an appropriate estimate of all which are 'canned' for the interior trade, and those sold in the shell for consumption in the Atlantic States; but of the trade from Virginia to Massachusetts, it is computed by the largest dealers in the industry that about 50,000,000 bushels are annually sold at 50 cents per bushel (25,000,000 dols.). But the following, copied from the Baltimore report of the industry in that single city for one year (1868), may give some idea of the importance of this crustaceous bivalve:—

"The trade in oysters has been in fair activity throughout the year. The number of houses prosecuting it now reaches about 73, of which some 40 are strictly in the packing trade. The hands employed equal probably 5,000 of both sexes in the various departments of shucking, packing, peeling, preserving, etc. Six to eight million bushels of oysters are consumed, one-third of which are packed raw, and the balance hermetically sealed. The cans required for these reach about 3,000,000 to 4,000,000, of half to one gallon each, and require say 300,000 cases to pack them. The balance of the oysters — some 4,000,000 bushels, are put up in hermetically sealed cans of 1, 2, and 3 lb. each, of which, during the active season, some 80,000 to 100,000 cans are daily packed, so that some 12,000,000 to 16,000,000 of cans are required for this trade annually. It is estimated that some 14,000,000 to 16,000,000 of dollars are invested in this interest in and around Baltimore, and that the annual product is worth some 6,000,000 to 7,000,000 dollars."

The number of vessels said to be engaged in that business on the Chesapeake is over 1,600, which gives employment to more than 6,000 persons.

It is encouraging to learn that America has been eminently successful in oyster-breeding. From Massachusetts to Florida, with more or less abundance, oyster-fisheries have been established, not only for dredging, but for cultivating. The result is, that this delicacy can be obtained at moderate charges, even in the interior towns and cities, such as St. Louis and Chicago; in fact, there is scarcely a respectable *table d'hôte* eastward of the Mississippi in whose bill of fare they are not to be found. "In the dominion where the winters are proverbially severe, they are equally abundant. New Brunswick, Nova Scotia, Prince Edward Island, and the estuary of the St. Lawrence, have long proved themselves prolific in this respect, corroborative of the fact that if you can get heat such as we annually have, it does not matter how severe the winter may prove for the abundant reproduction of these bivalves." Thus writes Ubique, who adds, "It has struck me that the American oyster may be of a different species from our own. The shape is not the same, and the flavour, I think, if possible, finer. If they are, could not the home-bred species be benefited by introducing the stranger? Experiment would soon elucidate this, for the American, if packed with the hollow side of the shell down, in solid masses, can be kept alive for months; in fact, I have been shown them thus stowed away in cellars, where they have been built in over ten weeks. What, then, would a voyage of ten days, under such circumstances, signify? The motion of the vessel might shake out some of their moisture (on which they subsist), but certainly not all."

The American oysters we have seen and eaten differ both from the French and English, having a nearly black *body*. They are of good flavour, and we are told can be purchased on the beds for £1 sterling a ton! Hitherto, several failures in their transit across the Atlantic have thrown a damp upon the speculation of their introduction into England, but doubtless ingenuity and perseverance will shortly devise some methods by which their perfect preservation will be secured. There is every hope of such a consummation, as small parcels almost invariably have arrived upon our shores in safety, as have likewise some few important shipments. The shape of the American oyster is, moreover, sharper, and more mussel-shaped than our natives.

If we might venture to make our own suggestions for the improvement of the oyster fisheries on our coasts, we would institute, in the first place, a general survey by the means of small steamers (tugs would be amply sufficient) carrying trawl nets and dredgers, so as to cover all the ground round our islands, and all beds when found, which doubtless very many would be, should be accurately marked upon a fish chart. We would have these public beds worked only every four or five years, and heavy penalties imposed for the possession and sale of spat, brood, and immature oysters of any description. We believe that if the dredgers were compelled to throw over all immature stock, taking the adult oysters would rather benefit than otherwise. These regulations should apply to all public beds as well as those newly discovered. At present, no sooner is a new bed found (and several have been accidentally met with within the last few years) than it is completely skinned, the dredgermen assembling from all parts carrying away adult oysters and brood indiscriminately—the former for immediate consumption, the latter for the preserves at the mouth of the Thames. We would have on board of these steamers a man thoroughly acquainted with the practical working of the dredge and trawl, and a superior officer of better education to keep a full record of all observations. By these means, which would be very inexpensive, we might hope to obtain fishing-grounds of great value. It is well known that fishermen, as at present constituted, will not waste their time or risk their nets by trying experiments, but, on the contrary, use their utmost speed to get to the fishing-ground of which they entertain the best opinion; the discoveries, as we have seen of late years, being entirely the result of chance, and not through any system of investigation. So wedded, indeed, are the fishermen to their own particular tracks, founded upon habit and the assured safety of the ground, that nothing would persuade them to risk their trawl or lose the whole expense of their trip in speculative trials. One great merit of this plan, we conceive, would be that of its economy; a tug-steamer with a crew of eight or ten men being fully sufficient for each section. The character of bottom and depths of water are already known and recorded in the maps of the Hydrographical Department, which information would, of course, be of great value in the investigation we propose. In beds and public fisheries there ought to be a constant inspection going on, and perhaps this could not be better entrusted to other than the coast-guard service, which, we believe, has but little of its old original work of looking after smugglers left to it to do. The information thus obtained should be transferred to the fish chart, and show the description of fish to be found in each locality. There is no doubt, in contradiction of all that is asserted and written to the contrary, that the supplies of deep-sea fish have really decreased, and considerably so during the last twenty years, in spite of the additional catching power, if we may so call it. In past times, the greater part of the vessels employed were vessels of ten to thirty tons, a very large proportion of which found employment close to our coasts, and brought their fish on shore every day. The vessels now principally employed are some sixty to seventy tons, handsomely built, and admirably equipped, which keep the sea for many weeks at a time, their fish being collected and brought to market by steam carriers; each of these vessels, while employing only an additional average crew of 50 per cent., having at least sixty times the average catching power, all circumstances being taken into account.

OYSTER AXIOMS.

Oysters breed in salt water, on a clean bottom.

Oysters fatten in brackish water, on a muddy or marly bottom.

Oysters are fit to leave the breeding-beds when two years old.

Oysters remain in the fattening-beds from one to two years.

Breeding oysters do not fatten, except on such ground.

Fattening oysters do not breed where there is much mud.

The natural oyster-beds of the United Kingdom are nearly all exhausted, being free to all comers, the demand being enormous, and continually increasing: the fishermen have dredged them bare.

Private breeding-beds are an actual necessity.

There is a demand for 100,000 acres of breeding-beds.

PATENTS AND PATENT LAW.—VI.

By a Barrister.

LEGAL PROCEDURE WITH REFERENCE TO PATENTS.

The proceeding in connection with patents most familiar to the lawyer, and with which patentees are most frequently concerned, is a suit for an injunction or for damages, or both, directed against infringers of a patent. In our last paper we dealt fully with the general question of infringement, so that we may here confine ourselves exclusively to procedure, which it is well every one interested in patent litigation should understand.

Most of our readers, probably, have heard of the proposed fusion of law and equity, a suggested reform in our law arising out of the monstrous injustice inflicted upon suitors by putting them first of all to the expense of a Chancery suit, and then turning them round to bring an action at law because the Court of Chancery was not invested with the power of awarding damages as a jury may do at common law. Some eminent lawyers, in their capacity of members of the House of Commons, addressed themselves to this grievance, without waiting for the larger reform which is inevitable. The late Sir John Rolt, a Lord Justice of Appeal in Chancery, and Lord Cairns, have passed Acts for the purpose of giving suitors complete redress in equity. The Act passed by Sir John Rolt says that in all cases in which any relief or remedy within the jurisdiction of the Court is or shall be sought in any cause or matter, every question of law or fact cognisable in a court of Common Law, on the determination of which the title to such relief or remedy depends, shall be determined by the same Court. This act was passed after Lord Cairns's, which more particularly affects patent suits.

Before Lord Cairns's Act (21 and 22 Vict., c. 27) damages could only be obtained at law, and where a plaintiff, in a case in the nature of a patent suit, prayed for an account, but afterwards desired to proceed at law for damages, he was not allowed to do so, except upon the terms of waiving his claim for an account. By the second section of the Act it was enacted that where the Court of Chancery has jurisdiction to entertain an application for an injunction against the commission or continuance of any wrongful act, it shall be lawful for the same Court, if it shall think fit, to award damages to the party injured, either in addition to or in substitution for such injunction. In the case of Betts against Neilson, Lord Chelmsford said that the object of this enactment was to empower Courts of Equity to deal with the question of damages instead of having to send parties for this relief to the Courts of Law. "There is nothing in the Act," he added, "to prohibit the court from awarding damages as well as decreeing an account. And the Courts of Equity having cases of this description entirely in their own hands, are able to administer full relief, which upon many occasions would not be obtained without both an account and an inquiry as to damages. The account and the inquiry as to damages have each of them a different object; one is to ascertain what loss the plaintiff has sustained; the other, what profit the defendant has acquired by the infringement of the patent. It might be that the party infringing had sold the patented article at an under-price, so that the amount of his profit would be no measure of the plaintiff's loss. And even in cases where there has been no such underselling, the plaintiff may have sustained damage far beyond what the gains of the defendant would compensate." It is then observed that in an earlier case for infringement of a patent, Lord Westbury, after directing an account, said, "That will be the whole of the decree unless the plaintiff prefers, instead of an account, to have liberty to bring an action at law for damages, which he may take in lieu of an account; if not, I direct an account as prayed." Lord Chelmsford comments upon this:—"But by his decree his lordship not only ordered an account of the profits made by the defendant by the making, use, and exercise of the plaintiff's invention, but also 'of such other compensation as is fit to be awarded to the plaintiff in respect of such making, use, and exercise.' It was suggested by counsel that the decree in this form was probably the result of an agreement between the parties, the defendant preferring to have the damages assessed by the Court instead of at law; but this will not explain away the fact of the decree being both for account and for damages, which shows that there is nothing irregular and improper in giving a plaintiff both these means of relief. It is so obvious to me that in many cases the account alone, or damages alone, will not satisfy the entire equity of a plaintiff in these cases, that there being nothing against principle, nor contrary to the enactment of the statute in granting the double relief, I shall hold the Vice-Chancellor's decree to be right in this respect."

We have quoted at some length from this judgment, because it is the most recent exposition by a high authority of the powers possessed by the Court of Chancery in giving relief to patentees who have suffered by acts of piracy. It will be observed, however, that whilst reference is made to damages nothing is said as to procedure by injunction. Suitors frequently elect to proceed at common law to recover damages whilst prosecuting their suit for an infringement, the old common law mode of trial being still in favour; and it has been expressly decided that in a suit for an injunction and an account the plaintiff may move to proceed with an action at law to try the right without previously moving for an injunction. The affidavit, however, on which such a motion is made must pledge the plaintiff's belief as to his title and the infringement of the patent right.

A suit being instituted for the purpose of restraining infringement by means of an injunction, the Court allows, at its discretion, discovery, which it need hardly be said is sometimes essential to enable a plaintiff to obtain redress. The Court, however, will not grant discovery unless satisfied that it may show or tend to show the fact of infringement. The defendant may, accordingly, though he denies infringement, be required to set out the names and addresses of his customers; or of persons from whom he has received sums of money as royalties in respect of goods manufactured by such persons in infringement of the plaintiff's right, though such persons may reside abroad; or to give particulars of the articles or machines manufactured, used, or sold by him, together with the price of the articles, the profits made on the sales, and other particulars. He may also be required to disclose whether he uses in his process the materials mentioned in the plaintiff's specification, whether he adds anything else, and whether such additions (if any) make any difference in the process; but he is not bound to disclose the nature and quantities of the additions. From the disclosures made under the discovery a plaintiff will frequently ascertain whether it is worth his while to proceed with his suit.

Supposing that he does proceed, the important question arises under what circumstances he will be entitled to an injunction. The ordinary rule of the Court of Chancery is that the legal validity of a patent must, in the first instance, be established, or that it must have been undisputed for a considerable number of years. But cases may arise in which the court will depart from this rule, as, for example, where the conduct of the defendant is open to suspicion, or where he has delayed unaccountably to take steps to oppose the suit. Having taken out a patent, the patentee may naturally consider that he has a right against any one using a similar invention. But it is quite open to a defendant to set up prior user, or show that the subject-matter of the invention is not the subject of a patent. This latter objection was taken in the case of a patent for improvements in ladies' veils, the same thing as the plaintiff claimed a patent right to do being proved to have been done repeatedly. It is always open to a defendant to prevent a plaintiff obtaining an injunction upon any grounds upon which the validity of the patent rests, and this he does by giving particulars of his objections, which particulars should be very carefully framed, as he will be confined within them on the trial. To give an example. In a suit to restrain the infringement of a patent for improvements in the construction of carriages, the alleged invention consisted of a particular mode of opening and closing the heads of carriages. Particulars of objections, which stated that head-joints similar to those used in the plaintiff's alleged invention had been, before the date of the patent, commonly used *by carriage-builders generally throughout Great Britain*, and that head-joints, similar to those described in the specification, had been actuated in their motions in the way described, before the date of the patent, *by various carriage-builders in or near London, Liverpool, Manchester, and Southampton, and various other of the principal towns of Great Britain*, were held insufficient. Vice-Chancellor Wood said that he should be disposed to tie the defendants down to specify the sort of carriage in which the alleged prior user took place, if he could not give the name of the manufacturer.

The courts are not at all strict in curtailing the right of objection of alleged infringers. A defendant in a suit for an injunction has been held entitled to dispute the validity of the patent, although the plaintiff has obtained a judgment at law against another person establishing its validity; but until he has proved its invalidity, he will be restrained from infringing it. Lord Romilly pointed out, in one of the numerous suits brought by the late Mr. Bovill, that it would be unjust, because one person has been unable to prove that the discovery was not new, to prevent another from doing so, and to bind him by a proceeding over which he had no control, and of which he knew nothing. His lordship added, "The consequence is, that in almost every case the patentee has to establish his case from the beginning against any fresh person who chooses to impugn the patent, and contest its validity." But, for the comfort of patentees, let us continue to follow this learned judge's remarks. "At the same time the law properly attaches to a patentee, who has established the validity of his patent, rights superior to those which belong to a patentee who has not done so. The former stands on a different footing, and though the patent may be contested by fresh persons, he will receive protection until the invalidity of it is shown. The distinction hitherto made by the Courts of Equity has been this: where the validity of the patent has not been the subject of any legal proceedings, that the patentee must prove its validity before a jury, before the Court of Equity will protect him; but having once established its validity, then the Court of Equity will protect him against any other person, until that person proves its invalidity."

It should perhaps be added here, though we confess the proposition strikes us as self-evident, that a plaintiff cannot recover damages by a suit in equity where it is practically impossible for him, at the time of filing his bill, to obtain an injunction to restrain the wrong complained of. A plaintiff filed a bill on the 8th of January, which prayed for an injunction to restrain the infringement of a certain patent and for damages. The patent expired on the 13th of January, and it was decided that as it was practically impossible for the plaintiff to obtain an injunction before the expiration of the patent, it was not a fit case for the interference of a Court of Equity.

Then arises the question what it is incumbent on the plaintiff to prove. Here again we are indebted to the enterprising Mr. Betts for information. Mr. Betts had manufactories for making capsules in France as well as in England, and the defendant in the suit suggested that the capsule used in the case of the alleged infringement might have been purchased at one of Betts's foreign manufactories. Lord Hatherley said—"I apprehend that the onus being on the plaintiff to show, not merely that the thing made is his own patented article, but that it has been unlawfully sold, he must be prepared to swear distinctly that it is not manufactured by him or his agent." And his lordship put the supposititious case of a man having three houses of manufacture, one in the north of England, one in the west of England, and one in London. "I cannot doubt," he said, "that it would be his duty, in making out his case before a jury, to prove not only that the article was of the same description as the patented articles, but that it was not made by himself; and for that purpose he would have to call as witnesses persons who had the control of his houses in the north and west as well as in London, to show that the article was not made by them."

There may be cases, however, in which the burden of proof is shifted. In a case very well known to patent lawyers, Penn *v.* Jack, it was laid down by a Vice-Chancellor that the onus of proving a particular alleged case of prior user rested upon the defendant. And where the defendant adduces such evidence, the plaintiff is allowed to bring forward evidence to rebut that of the defendant.

We have spoken of the remedies by injunction, or decrees for accounts and damages, for which latter an action at law may be brought as well as a suit in equity. To these measures of redress we may add that the machines shown to be an infringement of a patent may be ordered by the Court of Chancery to be destroyed. But this order will not be made as a matter of course in all cases. If it stop short of this extreme measure, it will, however, order them to be marked in such a way as to prevent their being used hereafter so as to continue the infringement. In the particular case which illustrates this point, the Vice-Chancellor said that, the patent being for a combination, the defendant might still use for other purposes the several parts of his machines.

And, lastly, a patent right may be slandered so as to give a right of action to the patentee in the nature of an action for slander of title. For instance, certain proprietors of a patent spooling machine brought an action against another proprietor of a patent spooling machine, for falsely and maliciously writing and saying to various persons in treaty with the plaintiffs for the purchase of their spooling machines, that the plaintiff's patent was an infringement of the defendant's, the defendant claiming royalties for their use, and threatening legal proceedings if these royalties were not paid, in consequence of which the plaintiffs lost the sale of their machines. The plaintiffs were defeated in this instance, as no intent *malâ fide* was proved; but Mr. Justice Blackburn said, "If the plaintiff had given evidence on which the jury might properly find that the defendant made the communication to the intending purchasers *malâ fide*, and without any intention to institute legal proceedings at all against the purchasers, so that it was not a step taken in support of his real or fancied right against the purchasers, but entirely out of malice against the plaintiffs," and knowing certainly that his claim was utterly without foundation, "we are inclined to think that it would have been proper to leave that evidence to the jury in support of the plaintiff's allegation that the defendant's letter was false and malicious." So that any warning given by a patentee to the purchasers or intending purchasers of the inventions of an alleged infringement must be *bonâ fide*, and with intent to assert a *bonâ fide* claim of right.

CONCLUSIONS.

It will have been seen that, although a great number of patent cases have come before the courts, the subject of patent law is not elaborate. The question of its reform is important, because it is difficult to see why inventors should be caused so much trouble and expense in procuring protection. The Society of Patent Agents, in a set of resolutions, have expressed their objections to the existing state of things. The chief defects of the patent laws are said to have arisen from a want of appreciation of the personal *right* of inventors to the sole use of their inventions, and the remark is made that "the true aim of legislation is to harmonise this personal right with the interests of the State." That is a vague sentence which it is difficult to understand. The interest of the State is to obtain as speedily as possible the benefit of inventions untrammelled by any personal right at all, and the only way to harmonise the personal right and the interest of the State seems to us to make them meet each other half-way as they do at present, the inventor obtaining the exclusive benefit of his invention for a certain period, and after that the State becoming the possessor. In the next place it is suggested that no mere importers of foreign inventions should be entitled to patents, and that every grant should be for a fixed period of twenty-one years, without the privilege of prolongation. As to expense, it is suggested that a fee of £10 for the entire term would be amply sufficient to secure an efficient administration of a simple patent system. The present cost of a patent is £175. Another resolution is that patents should be granted at the risk of applicants, without any official supervision of the specification or preliminary investigation of the merits of the invention. The only objection to this is that it might tend to check the spread of small discoveries which ought not properly to be subjects of a patent. An indiscriminate grant of protection to inventions would appear to us to have a mischievous tendency. Lastly, it is suggested that the rights of patentees should be determined by a competent tribunal, excluding all technical objections to the validity of the patent, and that jurors and expert witnesses should be dispensed with in patent suits. We have already expressed an opinion in favour of the first part of this suggestion, and in more than one case to which we have had occasion to refer we have seen the direst confusion arising out of the conflicting evidence of expert or scientific witnesses, so that the entire suggestion is based on common sense. It is, indeed, monstrous that patent law should have become so much of a science. It might be made very simple, and we shall have attained a useful object if, by the plain statement which we have put forward in these papers, we have made intelligible the existing state of the law and practice, and prepared any of our readers to understand and take part in the reforms which we trust are now pending.

SHIP-BUILDING.—XXIII.

BY W. H. WHITE,

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THE OPERATIONS OF SHIP-BUILDING.

UP to this point our aim has been to illustrate and describe the arrangements and combinations of the component parts in the *finished* structures of various classes of ships; now we propose to sketch the *order* in which the actual work of building ships is conducted, without, however, attempting to give details of the various operations.

Ships are usually built on *slip-ways*, sloping down to the water, and as the weights to be carried by these slip-ways are very great, care has to be taken to secure a good foundation. Upon the slips transverse piles of timber, termed "blocks," are erected at intervals of five or six feet, and are secured in place by struts, shores, etc. The upper surfaces of the blocks usually lie in an inclined plane, the slope of which towards the water is about ⅝ inch to a foot, and upon the blocks the keel of the ship is laid. In this common arrangement, therefore, the ship is built, *end-on* to the water, into which she is to be launched when completed, and the stern is generally, although not always, at the lower end of the slip. Cases have occurred, however, in which the lines of blocks have been laid parallel to the edge of the water, and the ships built *broadside-on*, so that they have had to be launched side-ways; the *Great Eastern* was so constructed at Millwall. It is not uncommon, also, to find regular slip-ways dispensed with in building small merchant ships, and recourse had to temporary and less costly arrangements. Every visitor to seaport towns must have observed instances in point, where small ships have been constructed on wharfs or quays, or in other places not specially prepared for the purpose.

Graving or dry docks have, of late years, been made use of for building many heavy ships, especially iron-clads. Such docks are, of course, very costly constructions as compared with slip-ways; but when they are available for the purpose, they offer much greater facilities for carrying on the work of building; and instead of launching vessels when completed, it is simply necessary to float them out. It is an interesting fact that quite a century ago, this practice of building in dock was tried in France, mainly with the intention of doing away with the severe strains incidental to launching ships from slip-ways, which strains were then regarded by many persons as the principal causes of the excessive hogging common in the ill-built wood ships of the period. After trial, however, it was found that this opinion was inaccurate, the ships built in dock having hogged very nearly as much as those built on slips, after they were afloat. The modern resumption of this practice is, as we have said, mainly based on considerations of convenience, and in illustration of this statement a brief notice of the plans adopted in the royal dockyards at Chatham and Portsmouth will not be out of place.

The blocks upon which the ship is to be built are laid at the centre of the floor, or bottom, of the dock. Along the sides of the dock, lines of railway are laid, upon which travelling steam-cranes are mounted, and by this means the materials brought to the dock-side can be readily placed in any position desired. Moreover, as the dock is excavated below the ground level, a very large part of the weights have simply to be lowered into place, only those connected with the upper works having to be raised. As compared with what has to be done in raising the weights of a ship built on a slip, even when the best appliances are provided, this is no small advantage; and it is of more importance when armour-plates, each weighing many tons, have to be wrought into the structure. Besides this, if desired, the hull of the largest and most heavily armoured ship can be completed with perfect safety in dock, before she is floated; whereas a similar ship built on a slip would almost certainly require to be launched before her armour was completed, and it would be advantageous in every respect to put her into a dry dock after launching, in order to complete the work. These and other advantages render it preferable to build such ships in docks, and enable the work to be done more quickly as well as more economically. One or two large private ship-building firms have also adopted this practice for iron-clad ships, but in most cases the dock accommodation is too limited to admit of its use.

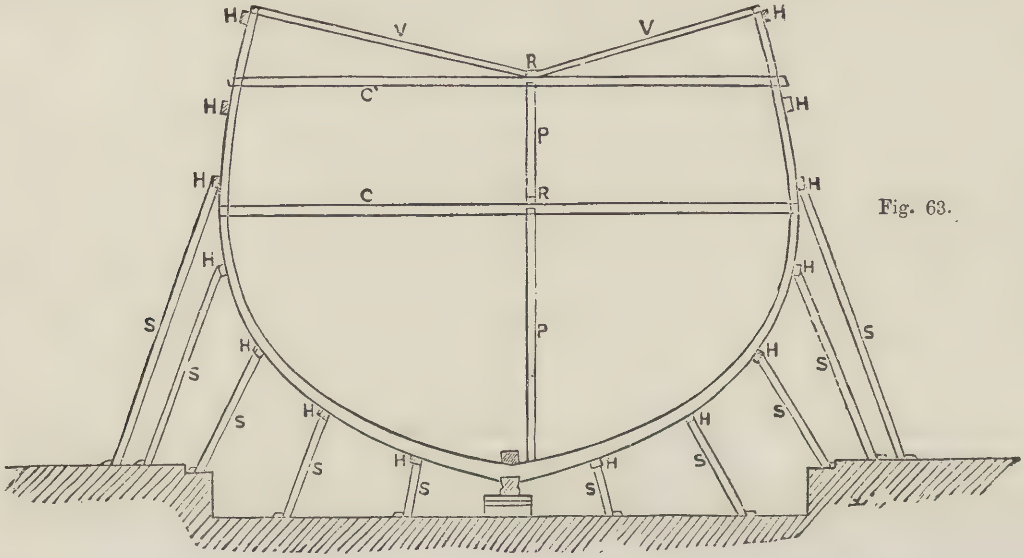


Fig. 63.

Space will not permit us to refer to the general arrangement of the workshops, plant, etc. etc., of ship-yards, although this is an important and interesting branch of our subject. We must at once pass on to notice the leading features in the ordinary method of proceeding with the construction of wood ships. For convenience, we will suppose the system of framing adopted to be that illustrated by Figs. 14—18, page 81, Vol. III.

The keel is first prepared and fixed in position on the blocks, and as soon as may be convenient the stem and stern posts are also put in place and secured. Next in order comes the "crossing of the floors"—*i.e.*, putting them into place, fitting them into their seating on the keel, dowelling them, etc. It is usual to put together each floor and its corresponding first-futtocks, as well as each pair of filling-floors, before they are crossed; and from what was previously said the reason will be obvious. This is really the first stage in the operation of "framing" a wood ship; it is usually begun amidships, and gradually carried forward and aft. While this work is proceeding, the deadwood, stemson, and other strengthenings near the extremities are prepared and fixed in place.

To make sure that the floors and filling floors are in their

correct positions transversely, a line or batten is stretched from some point in the middle-line of the keel to the corresponding heads or sirmarks on opposite sides, and the two measurements must, of course, be equal when the timbers are in place; this operation is termed "horning," and is applied in many other cases. To ensure the correct "stand" of the timbers in relation to the keel, large squares or bevels supplied from the mould-loft are often used. To prevent any chance of departure from symmetry in relation to the middle line, a batten is stretched across from side to side, and being fixed at corresponding heads or sirmarks, a spirit-level is laid upon its edge, or a plumb-bob is dropped from its middle point, which should, of course, be exactly over the middle line of the keel. These simple tests are described here because they are again and again applied in framing both wood and iron ships to ensure the symmetry desired, and to keep the frames in their correct positions.

When the adjustment has been carried out, the timbers are secured by means of a longitudinal "harpin" or "ribband," wrought along under the floors and secured to them, as well as supported by shores heeled upon the slip-way. To shorten our explanatory remarks as much as possible, we have in Fig. 63 given a rough sketch, showing a transverse sectional view of a ship in frame. H, H, H, represent harpins, and S, S, shores. These harpins, be it observed, are most important temporary securities, and are made to run from end to end of the slip, being usually placed in the neighbourhood of some head or sirmark. Amidships, where there is little curvature, the harpins are formed simply of pieces of fir of square section, upon which the stations of the various timbers are marked; these pieces are often styled "ribbands," and the term "harpins" is then applied especially to those pieces near the extremities which have considerable curvature, and require to be carefully trimmed to the moulds prepared in the mould-loft. From what has been said, therefore, it will be seen that the harpins and ribbands, when in place and shored, form a sort of cradle upon which the frame-timbers are supported and retained in their correct positions.

Reverting to the operation of framing, little need be added. In the case under consideration, the timbers forming the various futtocks are raised singly, and the work progresses as follows. A few of the "second futtock" timbers (see Fig. 16, page 81, Vol. III.), are put in place, their butts being dowelled to the floor-heads, and the accuracy of their position tested by horning and levelling. Then a harpin is fixed beneath them and shored, after which the remaining second futtocks, and other timbers crossing the harpin, can be rapidly put in place, and no trouble is required to test their positions, because their stations are marked upon the harpins. By means of a repetition of these operations the framing is gradually extended upwards, and at the same time it is carried forward and aft. In the cant-bodies the plan followed is almost identical with that sketched, only special care is needed in fixing the lower cant-timbers at their proper heights and "flights," or deviations from the transverse lines. When advanced thus far, further securities are provided for the frame by means of "cross-spalls" (C, C, in Fig. 63), stretching across near the heights to which the decks will be brought, and with these cross-spalls are associated longitudinal ribbands (shown in section by R, R), diagonal struts (such as V, V), vertical stanchions (P, P), and other means of preventing change of form in the framing during the subsequent operations. At this stage a ship is said to be "in frame," and formerly our wood ships of war were not uncommonly left in this condition for considerable periods in order to season the timbers.

Beyond this stage the order in which the work is conducted differs very considerably under various circumstances, and it would be idle for us to pretend to lay down a rule, or to attempt within the space at our disposal to describe in detail the various operations. It may be taken for granted that commonly the work of preparing and fixing the keelson will have been completed when the ship is framed; also that considerable progress will have been made in preparing the deck-beams and other pieces, as well as fitting the fillings between the frames. Before planking can be begun, however, the frame must be faired and "dubbed-out." The outer surfaces of the timbers are carefully trimmed to the form of the moulds provided, and are consequently very nearly fair when put in place on the harpins; but the inner surfaces are not so carefully treated, and require more fairing after the framing is complete. When this is done the iron riders can be fitted and temporarily secured, and the work of fixing the skin-planking can be commenced; while at an early period the preparation and fixing of shelf-pieces, ekings, hooks, etc., can be taken in hand.

Respecting the planking, it can only be said that the wales are usually commenced about the same time as the garboard-strakes, the operations of planking up from the garboards and down from the wales being proceeded with simultaneously, and the shutting-in strakes being fitted in some intermediate position, while the planking from the wales to the gunwale is worked upon independently. All such matters depend, however, upon the circumstances under which ships are built, and the degree of urgency with which they are pressed forward. So also do the steps taken in carrying on the inside work—framing the decks, working the clamps, ceiling, binding strakes, etc. In the Government service it is customary to carry these on at as early a period as possible after the outside planking has been begun, so that as many of the through-fastenings as possible may be made to serve as fastenings for the planking also, and no delay be caused in "squaring-off." These are matters which have already been considered in previous papers.

As the planking is proceeded with the harpins and ribbands are, of course, removed, and the shores are then placed under cleats fixed temporarily to the planks. Similarly, when the deck-beams are fixed in place, the cross-spalls can be removed, as they are no longer required to secure the frames, and are in the way of the further progress of the work on the decks—such as fitting the water-ways, letting-down carlings, framing hatch-ways, laying the deck-flat, fixing pillars, etc. It is important also to clear the hold as much as possible of the temporary shores and struts, in order that the work on the fitting of engine and boiler-bearers, hold-stanchions, transverse bulkheads, and other partitions, for store-rooms, etc., may be proceeded with, which works are generally well-advanced before ships are launched.

The above may be taken as a brief but clear and succinct account of the order, as we have already said, in which the work of building a ship is carried on. It will prove useful to the artisan engaged in any special branch of the trade, who may desire to make himself master of the method adopted in the early stages of constructing the framework of a vessel on which he may subsequently be employed in making the interior fittings or fixing the rigging; and also to the non-professional reader who may be visiting any of the yards, large or small, in which this trade is pursued. In the large shipping ports the work is carried on with activity and energy on a large scale; but in almost every small seaport town, especially in the west of England, wood ships are built for employment in the coasting trade, and in the fruit trade with the Mediterranean, Levant, etc.

MINING AND QUARRYING.—XXXI.

BY GEORGE GLADSTONE, F.C.S.

GOLD.

DISTRIBUTION—NATIVE GOLD—ASSAYING—AMALGAMATION—SEPARATION FROM SILVER—PROPERTIES—USES—MONETARY—STANDARD GOLD—JEWELLERS' GOLD—GOLD LEAF—GILDING—ELECTRO-GILDING—GOLD WASH—COLOURING PROPERTIES.

GOLD is very generally diffused over the surface of the globe; indeed, there are few countries of any extent which have not, at some period or other of their history, furnished sufficient gold to remunerate the explorer. As, however, it is almost always found in the metallic state, and is so easily recognised and distinguished from any other metal, those countries of the Old World which have been long and thickly inhabited, have long since yielded up their golden treasures to their former inhabitants.

At present, the United States of America contribute more than one-third of the total supply; and so do our colonies in Australia and New Zealand. The Russian empire supplies about an eighth; and the remainder is made up by a long list of smaller contributions. Europe, excluding Russia, figures in this list to the extent of about 1 per cent., almost all of which comes from the Austrian empire; though it is beyond

question that Spain, Italy, and Britain have in former times furnished considerable quantities.

More particularly now as to our own country. Grains of gold are now and then still found in Cornwall by the streamers for tin; in a limited area in the north of Scotland, gold washings fairly remunerate the labour expended; in North Wales systematic mining for auriferous quartz is conducted; and in Ireland a small fraction of gold in some of the pyrites of Wicklow adds to the commercial value of that mineral, as it is more than sufficient to cover the cost of separation.

We have already said that gold almost always occurs in the metallic or native state; nevertheless, pure gold is never met with in nature, it is always alloyed with silver. The proportion of the latter metal varies greatly, sometimes amounting to nearly two-fifths of the whole. The produce of Australia and New Zealand is remarkably pure, as it contains only about 3 per cent. of alloy, and is therefore considerably above the English standard. Neither California, nor any of the other countries of the world, supply gold which will on an average equal our standard. It is therefore necessary that every parcel of gold should be assayed before its market value can be arrived at.

Gold dust, the form in which the metal is usually found, is therefore melted and poured into ingot moulds; and each bar is then the subject of a separate assay. The plan officially adopted both here and in France is to take half a gramme, equal to 7·72 grains, of the gold bar, and cupel it with the addition of lead, and a quantity of silver estimated to be equal to three times the weight of the gold itself. The button thus produced is flattened out till it is about $\frac{3}{4}$th of an inch in diameter, annealed, and then rolled out into a riband of from $2\frac{1}{2}$ to 3 inches long; it is then annealed a second time, and rolled up by hand into a spiral form. The cornette, as this is called, is then put into a flask, and boiled in nitric acid, of 1·18 specific gravity, until nitrous fumes cease to be evolved. This acid is poured off, and the flask is then filled with acid of 1·28 specific gravity, in which the cornette is again boiled. By this time the whole of the silver has been dissolved out by the acid, and the gold has become spongy and very fragile. The whole of the acid must now be removed by careful washings in distilled water; the gold is then gently transferred into a crucible, in which it is heated just sufficiently to make the gold cohere, so that it can be handled without fear of loss, when it is removed to the balance and weighed.

Auriferous quartz is crushed under stamps on the spot where it is raised, and the gold separated from the matrix, usually by amalgamation with mercury, so as to save the carriage of useless material. If an estimate of the per-centage of gold in the quartz itself is desired, the average of a number of fairly-chosen samples should be taken; the quartz selected is reduced to a fine powder, and melted in a crucible with six or seven times its weight of litharge, and a little charcoal powder. The button of metal thus produced is then cupelled in the manner described in Article XXIX., on the assaying of silver.

When pyrites have to be assayed for gold, they are usually calcined first in a scorifier, until they cease to give off any sulphurous fumes; and then the roasted ore is treated in the same way as the auriferous quartz, except that some borax equal in weight to the ore is also added. In both cases, after cupellation, the silver must be separated by the action of nitric acid, before the final result in pure gold can be obtained.

A great variety of machines have been invented for the purpose of crushing and amalgamating the quartz and other auriferous rocks to the greatest advantage, but these are rather of interest to the people of California and other mining districts. The principle upon which the collection of gold by the agency of mercury is conducted may, however, be touched upon, as it is applicable to other purposes. The rock should be crushed or ground under water to an impalpable powder, and then washed down from the mill or stamps to the amalgamator. This is generally provided with a mechanical stirrer, by which the powder is worked up with the water into a pasty state. A quantity of mercury is then introduced, which must be more than sufficient to take up all the gold estimated to be present, and the stirring is kept up until the amalgamation is complete. The excess of mercury is forced out by pressure, and the soft cake of amalgam is transferred to a retort, to have the mercury distilled out of it. A very moderate heat is sufficient for the purpose, and one of the principal matters to attend to is the adoption of such an arrangement as shall effectually prevent the escape of any mercurial vapour, which, if permitted, would seriously affect the health of the workmen. The apparatus figured in the annexed drawing (Fig. 1) will answer the purpose. A B represents a round iron vessel made in two sections, which can be bolted together at the flanges; from the upper part of A, an iron pipe rises which is bent downwards, until it enters the receiver C. This is filled with water to a level slightly higher than the mouth of the pipe. The amalgam is placed in B, the upper segment then screwed down and well luted round the flange, so as to prevent the escape of any vapour, and a brazier with a lighted fire placed below the retort. The mercury, as it becomes volatilised, passes into the iron pipe, where it condenses and falls into the water contained in the receiver: as soon as the mercury ceases to come over, the operation is at an end, the fire is withdrawn, and when the retort has cooled, it is opened, and the gold taken out. The mercury is then available for another amalgamation.

Not only is silver so generally to be found in native gold, but many of the ores of silver, and hence also much of the silver money coined abroad, contain more or less gold. It is evident from what has gone before that the more valuable metal can be separated from the other by the agency of nitric acid; but in conducting this operation on a large scale, it is found more economical to substitute sulphuric for nitric acid. The metal is first granulated, by throwing it while melted into cold water; and then it is boiled up with sulphuric acid in iron tanks. The silver is thus completely dissolved, leaving the gold untouched, which is then allowed to settle to the bottom. The silver solution is then drawn off into other tanks, and the gold being collected is washed, and melted into bars. The whole of the silver is recovered by placing sheets of metallic copper in the solution; when the silver, having less affinity than the copper for the sulphuric element, crystallises out at the expense of the other metal, which in turn is converted into the sulphate.

Pure gold possesses the great advantage of not tarnishing on exposure to the air, and indeed it is altogether unaffected by almost the whole catalogue of chemical elements. It will combine with chlorine to form a salt, and it is soluble in a certain mixture of nitric and hydrochloric acids; but these are about the only exceptions beyond that of entering into alloys, and some double salts. It is remarkably heavy, the specific gravity being 19·3, is moderately soft, and highly ductile and malleable, so that it can be drawn into very fine wire, and beaten into very thin leaf.

Amongst its uses, that of a medium of exchange deserves first notice. Its cleanness and convenience specially recommend it for a metallic currency, but the pure metal would be too soft to stand the constant wear, and a standard alloy with copper is therefore adopted, containing 91·67 per cent. of pure gold, or 22 carats fine, the pure metal being reckoned as 24 carats. No uniform international standard of fineness has yet been agreed upon, so that the standard of the country must be taken into account in calculating the intrinsic value of foreign gold coin.

Still more uncertain is the fineness of the gold used by the jeweller. It is, in fact, alloyed in various proportions, either with silver or copper, according to the colour that may be desired. Thus, if a red gold is wanted, the relative proportions will be about 75 per cent. of gold to 25 per cent. of copper; and by substituting silver for copper in similar quantity, a greenish coloured gold will be produced. These, in the language of goldsmiths, will be 18-carat gold. For some purposes a still larger proportion of silver is employed.

On account of its great cost, gold can be used only sparingly except in special cases. Nevertheless, in consequence of its rich colour and its non-liability to tarnish on exposure to the influences of even the vitiated atmosphere of our large towns, it is the metal which above all others is used for decorative purposes. Few even of the poorest in our land cannot produce some article or other into the composition of which gold has not entered.

A necessary contributor to this result, however, is its great malleability. A single grain, the first cost of which is about twopence, can be beaten out into leaf which shall cover 75 square inches, though for ordinary purposes it is not carried to

this degree of fineness. A little gilding can therefore be enjoyed at a very moderate outlay. The mode in which gold-leaf is prepared is worth study, and then the various ways in which it may be employed will call for attention.

Gold-beating has for a long time been an important business in the neighbourhood of Clerkenwell; London indeed having always stood pre-eminent in this industry. Pure gold is softer and more malleable than any of its alloys, but leaf made from it is more tender and less economical in use than that made of an alloy containing a moderate proportion of either silver or copper. Which and what quantity of the cheaper metal shall be used depends partly on the question of colour: in either case the operation is the same.

The gold is first melted at a high temperature, and run into ingots of about two ounces in weight; these are afterwards rolled out between steel rollers into ribands of an inch and a half wide, and of such thickness that a strip ten feet in length shall weigh an ounce. The metal will have become more brittle under this operation, and must be annealed by heating it, before it can be further dealt with. It is then cut up into squares of an inch each way, and these are placed in a pile with a leaf of fine vellum or parchment paper between each, the bundle so made being called a "cutch," and then the actual beating commences, with a hammer of 17 lb. weight. After about twenty minutes the squares of gold will have spread out to about four times their original dimensions; and they are then taken out, cut into quarters, and made up into another pile, called a "shoder," the alternate leaves being made of goldbeaters' skin. The shoder is beaten with a lighter hammer for about two hours, until the gold has again expanded in like degree. These leaves are again quartered and carefully beaten a third time between goldbeaters' skin of the finest quality, with a still lighter hammer, which reduces them to the thinness customary in the trade. The edges are then trimmed, and the leaves transferred into the little books in which they are sold. 100 square feet of ordinary gold-leaf will weigh an ounce.

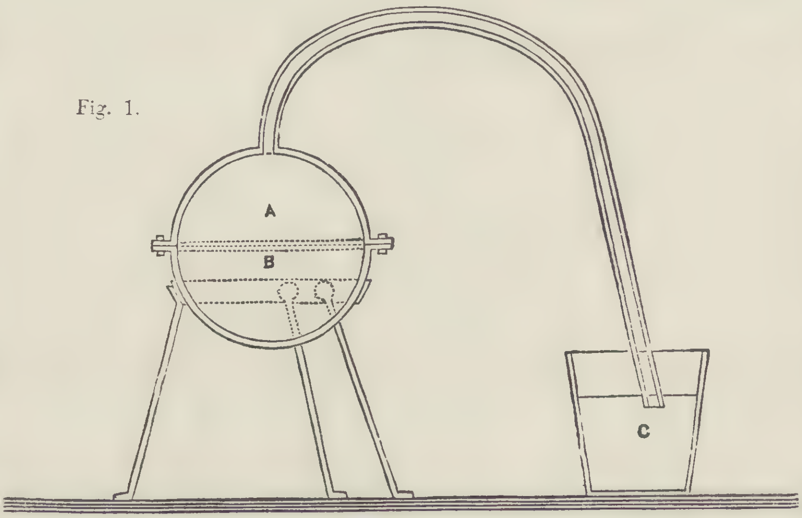
There are various ways of applying gold-leaf, dependent upon the material which has to be gilded, and the effect which is desired to be produced. In gilding cornices, looking-glass and picture-frames, etc., the solvent in the composition to which the leaf is made to adhere may be either water or oil; the latter is distinguished as oil-gilding, and though less used, has the advantage over the former of bearing cleaning better. The size used for the more ordinary process consists of a mixture of plumbago, red chalk, pipe clay, bullocks' blood, and suet; this is melted with some ordinary clear size, and laid evenly on the moulding with a fine brush. Before the gold-leaf is applied the size is moistened with a little water. If a dead surface is desired, the gold has only to be washed over with very thin clear size; but if bright, the gold is polished by being rubbed with an agate or steel burnisher.

In oil-gilding the size used is made of a mixture of boiled linseed oil and ochre. The gold-leaf is applied before the oil has become quite dry. The mode of laying it on, and the subsequent burnishing of the parts intended to be bright, are the same as in the other case.

The lettering or otherwise ornamenting book covers, whether of leather or cloth, is done by the pressure of a hot metal block corresponding to the intended device. A little isinglass or white of egg is first spread over the surface in the case of leather; the gold will adhere sufficiently to cloth without either. On the cover being taken out of the blocking-press the superfluous gold is brushed off.

The gilding of metals is done by a very different process. The principal application of gold in this way is in the manufacture of jewellery, ornaments, and household utensils, and the agency by which this is nearly always done now is electricity. A liquid solution of a gold-containing salt has to be prepared, the aurocyanide of potassium being used for the purpose. To make this the gold is dissolved in aqua regia (three parts of hydrochloric acid to one of nitric acid), which will produce the terchloride, and by digesting this with calcined magnesia the gold will be precipitated in the state of oxide. In this condition it can be dissolved in a solution of cyanide of potassium, forming the double cyanide above named. As, however, a battery must be at hand for the gilding process, the most convenient plan is to employ the same agency for dissolving the gold in the first instance. To do this it only requires that a plate of pure gold be placed in a bath of cyanide of potassium, and connected by a wire with the positive terminal of the battery, while a sheet of copper or iron, connected with the negative terminal, surrounded by a porous cell filled with the same liquid, is placed immediately opposite to the gold plate. The precious metal is allowed to dissolve until a gallon of the solution contains from one half to an ounce of gold; the precise strength most suitable is dependent to some extent upon the description of articles to be plated. These are commonly made of silver, copper, or some of the copper and zinc alloys described in Article XXII., which in point of colour bear so striking a resemblance to gold itself. Before being placed in the bath to be gilded they must be rendered perfectly free from both grease and oxide, or the gold will afterwards be apt to scale off. They are, therefore, first boiled in caustic alkali in order to saponify and render soluble all traces of grease, and afterwards dipped for a moment in pickle which consists of a mixture of nitric and sulphuric acids and water, and then plunged into distilled water. From this they are transferred to the gold solution, which is kept at a temperature of not less than 130° Fahrenheit, and in the course of a few minutes the articles immersed will be sufficiently gilded.

Fig. 1.



Trinkets are very frequently washed with gold, which is done by forming the metal into an amalgam with mercury. The two metals readily combine in this way on throwing small pieces of gold heated to redness into a bath of warm mercury, and the product is a soft yellowish mass. The metal to be gilded by this process is rubbed over first with a solution of mercuric nitrate, which not only serves to clean the metal, but also deposits a part of its mercury upon the surface; and this assists in securing the adhesion of the amalgam, which is afterwards applied with a brush. The articles have then to be exposed to a gentle heat to expel the mercury from the amalgam by volatilisation, when metallic gold will be left as a thin coating over the surface. It then presents a dull appearance, and has to be rubbed and burnished in order to produce a proper effect.

Except for the purpose of gilding, the few salts of gold that can possibly be made are little used. The chief exception to this lies in their use as a colouring material. The oxide, either alone or in combination with a tin salt, will produce, either in glass or enamel, a series of reds and purples of very great depth and brilliance, and is therefore largely employed by stained-glass manufacturers.

HOROLOGY.—I.

By A London Watchmaker.

WATCHES: THE ARRANGEMENT OF THEIR COMPONENT PARTS.

As we have already given in Vol. I., pp. 166, 190, and 253, of this work a general review of the history of clock and watch making, including descriptions of some of the fantastic uses of the art, it is now our purpose to investigate the present methods and principles according to which the portable timekeeper or "watch" is constructed; and in so doing we shall reject all questions of priority of invention of any particular parts, stating simply how, and in what manner, the average good watch of the present day is made; prefacing our statements, in all cases, with such general introductory observations as may be necessary for the better elucidation of the subject. We trust that we shall be able, in this manner, to present to the general reader a mirror in which he may see where improvements may be necessary, and how far the watchmaker is entitled to the claim that he makes of being ranked amongst the "scientific artists" of his time.

We shall observe, with as little digression as possible, the following order in treating of our subject:—

1. Arrangement of the various parts.
2. Construction of the same.
3. General notions of the lever escapement.
4. General notions of the chronometer escapement.
5. General notions of the duplex escapement.
6. General notions of the horizontal or cylinder escapement.
7. Methods of making and applying the pendulum spring, and of obtaining its isochronism.
8. Manipulation of compensation for errors due to variations in temperature.

Fig. 3.—DRIVING-WHEEL SEEN FROM BELOW.

Fig. 3*a*.—DRIVING-WHEEL SEEN FROM ABOVE.

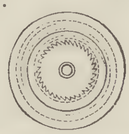


Fig. 7.—BODY SEEN FROM BELOW.

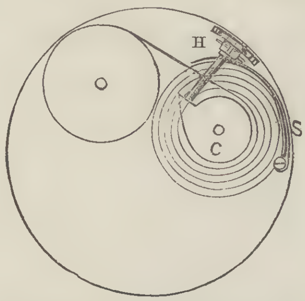


Fig. 4.—CYLINDER AND FUSEE WITHIN DRUM OR BARREL.

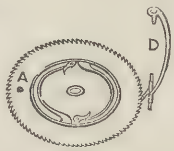


Fig. 6.—RATCHET WHEEL IN FUSEE AND DETENT.

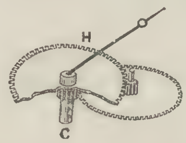


Fig. 5.—CENTRE WHEEL.

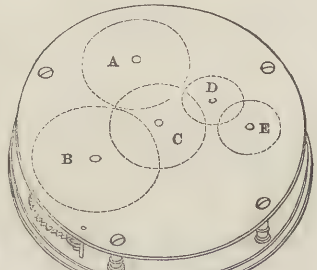


Fig. 1.—DRUM OR BARREL OF WATCH.

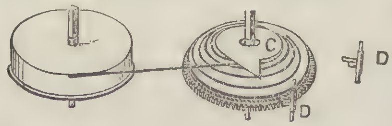


Fig. 2.—FUSEE AND CYLINDER.

ARRANGEMENT OF THE VARIOUS PARTS.

The first portable timekeepers made for carrying on the person having been egg-shaped, acquiring later a flattened spherical form, and taste and civilisation having demanded that time should be kept without such encumbrances as were these instruments to their users, they are now made as circular discs, nearly flat, and measuring about two inches in diameter, by half an inch in thickness; convenience has thus usurped the rights of economic and advantageous construction, for, had these been consulted, our best watches would now have assumed the shape of a gentleman's card-case or snuff-box, *i.e.*, rectangular, oblong, or of a dwarf spectacle-case, seeing that no corners are necessary. The reason of this will be explained in the consideration of construction of the parts.

The circular form having then been adopted, we have now to consider what our disc is to contain, our primary object being to convey to the sense of sight some certain indications by which the course of the march of hours may be exhibited.

This is effected by affixing hands or pointers to the ends of the spindles of certain wheels, which are made to travel at fixed relative speeds by means of cogs or teeth, by means of which one wheel cannot turn or make one rotation without giving a definite amount of regular motion to its neighbour—say for one turn of A, ten turns of B, or *vice versâ*.

The wheels themselves are fixed upon arbors or spindles, which are held in their relative positions by plates of brass which are screwed together. The object of these teethed wheels is twofold—namely, to transmit the power or force which is generated in a drum or barrel (Fig. 1), and by virtue of the varied number of their teeth or cogs to preserve the fixed ratio of speed necessary to cause the hands to revolve at the required pace.

The force is obtained by coiling round the spindle of A (Fig. 1), and inside the brass barrel a steel riband, called the mainspring, one end of which is pierced through and hooked on to a small protuberance in a solid steel cylinder fixed to this arbor, and the other end of which is fixed into the side of the barrel by a hook riveted into the thickness of the riband, and filed square to adjust itself into a mortise filed in the side of the barrel.

This steel riband, which is hardened and tempered, is somewhat coiled before placing it in the barrel, otherwise when bent, so as to enter the barrel, its tension would be so great as to cause each superposed coil to press so hardly upon the adjacent exterior one as to offer too great a resistance to its circular motion, and thus render the remaining force available for turning the barrel almost useless.

The spring has consequently a spiral shape, of a diameter about five times that of the barrel before it is placed in it.

The arbor is free to turn in the barrel, which in Swiss watches communicates its power direct to the centre wheel (C), which carries the minute-hand, but which in English watches transmits its force first to a fusee by means of a steel chain passing round either, and having its ends fixed by hooks in the opposite ends of these two cylinders.

The fusee is a conical cylinder, and has a groove cut in its surface to prevent the chain slipping (Fig. 2).

The barrel arbor has a ratchet let on to a square filed upon it at one end projecting outside the lower plate, upon which is a spring-click to prevent the arbor turning back when the spring is wound round the steel cylinder, which forms part of the arbor and is inside the barrel.

This steel cylinder is one-third the diameter of the barrel, to give the spring a sufficient leverage from the centre of the barrel, and to prevent breakage of the latter through being too sharply bent. Both ends of the spring are, in addition to this precaution, slightly softened from their tempered state.

In the Swiss (as in some of the modern English) watches the barrel has teeth upon its periphery, which gear into the pinion of the centre wheel, the barrel itself turning by the force of the spring, which is bent or coiled round the steel cylinder by a key adjusted to the end of the barrel arbor passing through the upper plate. This method has the disadvantage of giving greater power when the spring is tightly wound up than it does when half or more of its tension has been relaxed, by the gradual unwinding of its coils towards the outer part of the barrel.

To remedy this inequality, the fusee was introduced, by which the barrel delivers its force through a series of levers, growing longer as the power diminishes, to the pinion of the centre wheel; this is effected by the chain winding itself round the barrel off the conical and grooved fusee, drawing the chain first from the small diameter, and as it winds towards the other end of the barrel which is opposite, the larger diameter of the

fusee acting upon the centre of the fusee at points farther and farther distant from it as the mainspring power becomes less, and thus equalising the power.

It has been attempted to gain the same end by making the riband with a diminishing thickness towards the outer end; but this method has the disadvantage that the inner stronger coils carry the outer weaker ones all to the outside of the barrel at once, instead of allowing it to pass over coil by coil, and thus losing a great deal of power by the rubbing of one coil against another: the best method, therefore, of procuring a constant and equal force is found in making the barrel rather larger, and using a long spring, which, when adjusted for use, is never fully wound up, and is never quite relaxed, the middle coils only being used.

When a fusee is used, the spring is bent, or—as the common expression runs—the watch is "wound up," by a square on the fusee arbor, which, turning the fusee, draws the chain off the barrel, and so coils the spring tight and close, by drawing round its outer end. Now, as by using too much force and winding too far the chain or spring might be broken, an ingenious method has been devised for preventing the fusee being wound more than sufficient turns for storing in the barrel power enough to cause the watch to go about thirty hours.

The fusee with this appliance is composed of three parts—the arbor with the grooved cone fixed to it; the driving-wheel, placed lowest in sketch (Fig. 2), capable of turning upon the arbor; and a wheel, usually of steel, placed between the brass-grooved body of the fusee and the driving-wheel, having sloping or ratchet-cut teeth upon it.

The driving-wheel (Figs. 3, 3*a*) has let into a space turned in its upper surface a circular spring, into one end of which is screwed a short steel pin (A) projecting upwards, the other end being screwed fast to the wheel. The steel ratchet has fixed upon its upper surface two clicks with springs throwing them inwards, which clicks act upon a small brass ratchet screwed to the under surface of the body of the fusee.

This steel ratchet has a small hole drilled near its circumference, into which the pin of the spring in the driving-wheel fits. Thus the body of the fusee may be turned to the left (looking from the top of the movement or watch-frame) without turning either the ratchet or driving-wheel, its ratchet acting upon the clicks in the steel ratchet. But when the barrel draws the body round to the right, its brass ratchet carries with it the steel ratchet (by means of the clicks fixed upon the latter), and this draws the driving-wheel with it, by the pin in its spring. But the driving-wheel is held by the pinion of the centre wheel, therefore the ratchet first bends the circular spring a little; its circular motion is determined by the pin projecting on the lower side of the spring into a slot or mortise in the great wheel.

As the escapement (to be described later) releases the wheels and allows the centre pinion to turn, so the fusee with its ratchet and body turns to the right; the ratchet is prevented from returning by a click or detent, D (Fig. 2), pivoted between the upper and lower plates of the watch.

Thus the first portion of the power of the mainspring, when bent up, is expended in bending the circular spring in the driving-wheel, the ratchet at the same time being drawn a few teeth past the detent D; then, at whatever time the watch is again wound, this circular spring in unbending itself drives the great or driving-wheel during two or three minutes, or so long as the key is held on the fusee body arbor square, until it is released, although during winding no power is derived from the mainspring. This arrangement is called the "maintaining power," and has the effect of keeping the watch going while being wound.

The Swiss and English watches without fusee require no such contrivance, as the action of winding only tends to add power to the barrel, as its motion is not reversed, the spring being wound from its inner and not its outer end.

Fig. 4 shows H, a small piece of steel pivoted between two brass jambs fixed on to the lower side of the upper plate, and held away from it by the spring S, but which, when pressed to it by the rising of the chain on the fusee as the watch is wound, butts against the cap of steel, C, fixed on the top of the fusee-body, and so prevents the spring in the barrel being wound too far.

Besides affording the means of equalising the power of the spring, the fusee is useful in another way—namely, in multiplying the movement of the barrel; for as several of its diameters off which the chain winds are smaller than the uniform diameter of the barrel, four turns of the latter are sufficient to give five or six turns to the former; on the other hand, power is lost through friction, and the fusee, besides occupying a great deal of space in the watch, is costly; besides which, its use brings another fragile part, the chain, into the watch's construction, and its interior arrangements are an additional cause of expense in repairing the watch.

Wheel D (Fig. 1), called by watchmakers the "third wheel" (being the third from the fusee—the barrel, having no teeth, not being deemed a wheel), serves simply as a multiplier; wheel E (the "fourth wheel") makes one revolution in a minute, and in watches in which it is intended to show the seconds upon the dial, this wheel has a long pivot passing through the lower plate and dial, and carries the seconds-hand.

English watchmakers call the plate on the dial side of the watch the "lower plate," or "pillar plate," because brass pillars are riveted into it. The plate which is screwed on to the tops of these pillars is called the "upper or top plate."

The next wheel after the "fourth" varies in its appearance and number of teeth, according to the escapement which is given to the watch.

The last wheel or "balance" vibrates "to and fro," it being found that this motion does not accelerate as does the revolving fly, especially when governed by a "pendulum spring," so called by reason of the "balance" having been devised to imitate the motions of the pendulum.

The pinion of the centre-wheel (Fig. 5, H) passes through the "lower plate," and besides carrying the minute-hand, with which it revolves once in an hour, carries also a steel pinion, drilled through its axis, and fitted almost tight on to the projecting pivot, which is turned somewhat large for strength. This gears into a wheel which runs on a steel pin screwed into the lower or dial side of the "lower plate," which wheel itself has a pinion turning a wheel running on the hollow pinion.

This wheel is made to travel at $\frac{1}{12}$ of the speed of the centre-wheel pinion, and carries the hour-hand.

In this manner the hour-hand and minute-hand revolve from the same centre, and in the same direction. The wheel H is called the "hour-wheel;" the pinion C, upon which the minute-hand is fixed, is called the "cannon-pinion," being drilled through as a cannon. The object of its not being fitted perfectly tight upon the centre pinion is that the hands may be set backwards or forwards, which they could not be were the minute-hand (through which motion is communicated to the hour-hand) fixed directly upon the centre pinion.

The wheels are all made of brass, well hammered; the pinions of hardened and tempered steel.

Within certain limits a thick watch is preferable to a thin or flat one, as it allows the wheels to be placed farther from the ends of the arbors, whereby the effect of wear upon the pivots or in the holes does not tell so much upon the pitchings or "depths," seeing that one end of the arbor always bears more strain than the other, except in the case of the barrel, which being in the centre of its arbor, gives equal strain upon each pivot, and seeing that the end which is the soonest worn is that immediately nearest to the depth.

Also, in flat watches, any dust getting into the movement more readily affects its going—in fact, sometimes stops its motion entirely, the wheels passing laterally so close to one another.

It will be useful, in recapitulation of what we have already said, once more to draw attention to the figures which accompany the present paper. Fig. 1 shows the brass drum or barrel of the watch. A is the steel cylinder holding spring, B the fusee, C the centre wheel, D and E the third and fourth wheels. Figs. 2 and 4 exhibit, the former an elevation of the spring cylinder and fusee, and the latter a plan of the same, while Fig. 6 shows how the detent, D, acts on the ratchet. Figs. 3 and 3*a* show the driving-wheel from above and below; while Fig. 5 shows the centre wheel, and explains the method of attaching the minute and hour hands. Fig. 7 is the body as seen from below. From this brief description we trust that the arrangement of the component parts of a watch can now be fully understood even by a non-professional reader.

TECHNICAL DRAWING.—LXXXVI.

DRAWING FOR METAL-PLATE WORKERS.

In order that the student may be able to draw the various forms required in "development"—that is, the covering of surfaces, which forms such an important portion of the trade of the metal-plate worker—it is necessary that he should acquire a sound knowledge of the geometrical methods by which the various figures may be constructed with correctness and accuracy.

In "Practical Geometry applied to Linear Drawing," which will be found in the first volume of The Technical Educator, an important system of lessons is worked out. To these, therefore, the student is referred for all elementary constructions, and the following figures are added as being specially useful in the branch of trade to which the present course is devoted.

The student is, however, urged to remember that he cannot hope to succeed in these and the subsequent figures unless he thoroughly understands the preceding ones. He may perhaps be able just to *copy* the drawings, but this is far from being the object with which he should set out.

The right-thinking student will need no argument to convince him that attempting to follow a special branch of a subject, without having previously mastered the elementary portion, will lead to a false result, and will be so much time wasted.

We would, therefore, impress on all who would benefit by these lessons the absolute necessity of working through the lessons already given under the heads of "Practical Geometry" and "Projection."

The methods of inscribing circles in triangles and squares have been given in the course above referred to, and those constructions are now supplemented by the following figures:—

Fig. 626.—*To inscribe within a given equilateral triangle three equal semicircles, having their diameters adjacent and equal.*

Let A B C be the equilateral triangle.

Bisect the angles of the triangle by lines A *a*, B *b*, and C *c*.

Join *a b*, and on this line describe a semicircle touching the sides of the triangle.

To avoid confusion of lines, this semicircle is omitted in this figure, the point only (*d*) where it would cut *b a* being shown.

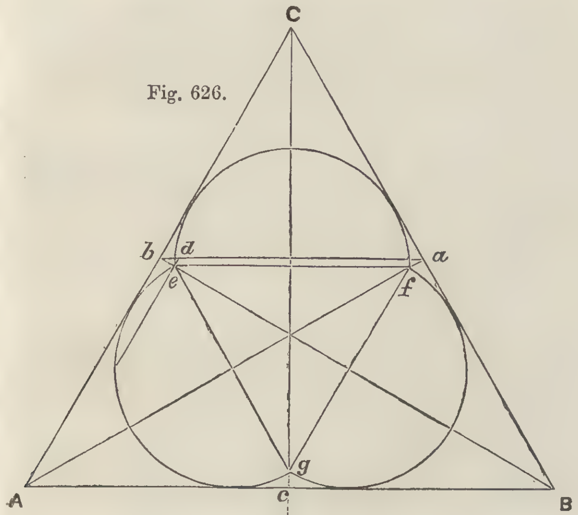


Fig. 626.

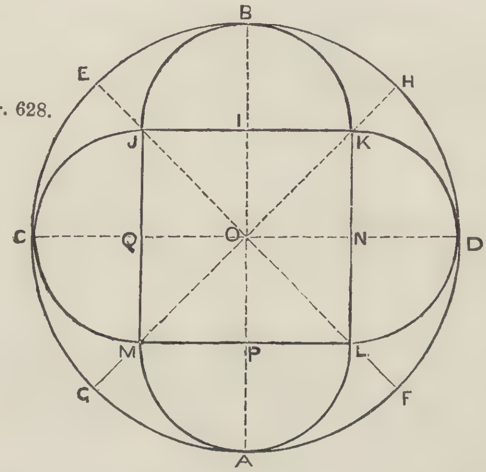


Fig. 628.

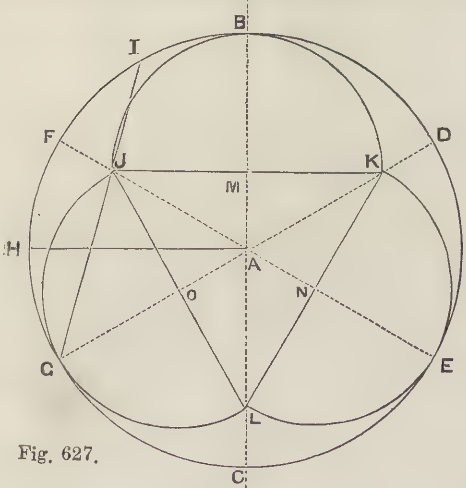


Fig. 627.

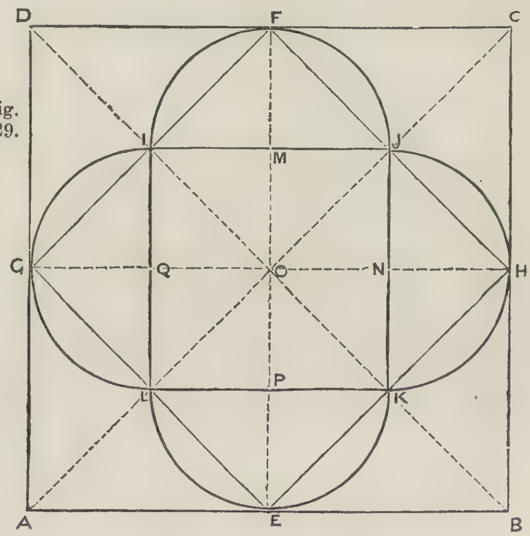


Fig. 629.

From *d* draw a line parallel to C A, cutting *b* B in *e*; from *e* draw a line parallel to *b a*, cutting A *a* in *f*.

Draw *f g* parallel to C A.

Join *g e* by a line parallel to B C.

Then *e f*, *f g*, and *g e* will be the adjacent diameters of three semicircles, the diameters of which are adjacent, and the curves of which will touch the triangle A B C.

Fig. 627.—*To inscribe in a given circle, three equal semicircles having their diameters adjacent.*

Find the centre of the circle, A.

Draw the diameter B C, and from B and C set off the radius of the circle, at F, D, and G, E, thus dividing it into six equal parts.

Draw E F and G D.

Draw the radius A H at right angles to B C.

From F set off F I equal to F H, thus trisecting the quadrant H B in F, I.

From I draw a line to G, cutting E F in J.

From A set off A K and A L equal to A J.

Join J K, K L, and L J, which will give the adjacent diameters of the three required semicircles, the centres of which will be at M, N, O.

Fig. 628.—*To inscribe four equal semicircles, having their diameters adjacent, in a circle.*

Draw two diameters at right angles to each other, A B and C D, intersecting in O.

Bisect the quadrants in E, G, F, H.

Bisect O B in I.

Draw a line through I parallel to C D, cutting E F and G H in J and K.

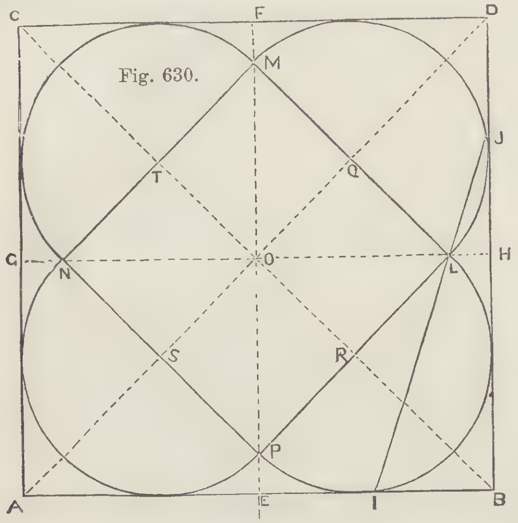


Fig. 630.

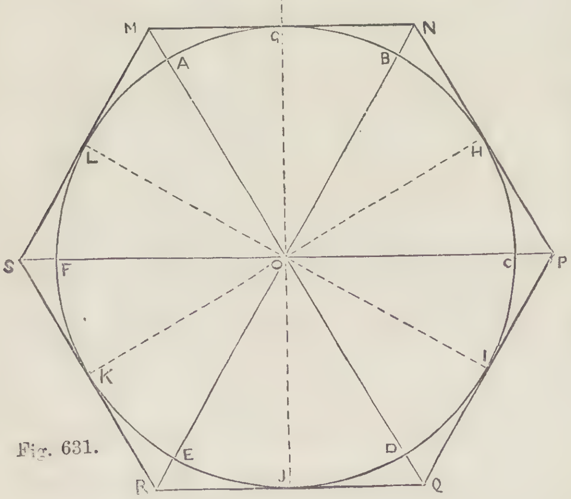


Fig. 631.

Draw K L and J M parallel to A B, and join M L. Then the sides of the square J K L M will be the adjacent diameters of the required semicircles of which I, N, P, Q will be the centres, and I B the radius.

Fig. 629.—*Within a given square to inscribe four equal semicircles, each touching one side of the square and having their diameters adjacent.*

Let A B C D be the given square. Draw the diagonals A C and B D, intersecting in O.

Through O draw E F parallel to B C, and G H parallel to A B, thus dividing A B C D into four smaller squares, each having one diagonal.

Draw the second diagonal in each of these smaller squares, cutting A O, B O, C O, and D O, in L, K, J, I respectively.

Draw I J, J K, K L, and L I, thus constructing the square, the sides of which will be the four adjacent diameters of the semicircles, which may then be drawn from M, N, P, Q, with radius M F.

Fig. 630.—*Within a given square to inscribe four equal semicircles, each touching* TWO *sides of the square, and having their diameters adjacent.*

Let A B D C be the given square. Draw the diagonals A D and B C, intersecting in O.

Through O draw E F and G H parallel to A C and A B.

Bisect E B in I, and D H in J.

Draw I J, cutting G H in L.

From O, set off on the diagonals, O M, O N, and O P, equal to O L.

Join L M, M N, N P, and P L, and a square will be constructed, the sides of which will be parallel to the diagonals of the original square, which will intersect the sides of the square L M N P in Q R S T. These points will be the centres for the required semicircles, the radius of which will be Q L, etc.

Fig. 631.—*To describe a regular polygon about a given circle.*

The required polygon is in this case a hexagon.

Divide the circle into six equal parts (this number will, of course, vary with the required number of sides of the polygon), and draw radii A, B, C, D, E, F, producing them beyond the circle.

Bisect the angles thus formed in G, H, I, J, K, L.

Draw tangents to each of these radii, which, meeting in the produced radii A, B, C, D, E, and F, will form the required polygon about the circle.

The method of drawing a tangent at a given point is shown in "Lessons in Practical Geometry applied to Linear Drawing." It is only necessary to go through this operation once in the present figure.

Thus the tangent drawn at G will cut the two radii O A and O B in M and N.

From O, with radius O M or O N, describe a circle cutting the radii O C, O D, O E, and O F in P, Q, R, S. Join these points, and a hexagon will be constructed about the circle.

FISH CULTURE.—XV.

By GREVILLE FENNELL.

IMPORTANCE OF THE OYSTER AS AN ARTICLE OF FOOD—MUSSEL CULTURE IN FRANCE—MUSSEL CULTURE IN ENGLAND—THE NACRE.

THE oyster is truthfully described as the most delicious and highly appreciated of all shell-fish. It is the most wholesome of all food, never disagreeing with the most delicate stomach. It is highly nutritious, and eminently digestible. Having these good qualities, the oyster has been sought, as a luxury, by all European nations; but in London the artisan class have long recognised its value as an aliment, and immense numbers of the coarser descriptions are annually sold in the streets of this city. Thus consumed by all classes, the demand has gradually exceeded the supply; prices have risen, beds have been exhausted, and in 1865 the best natives were £6 a bushel, wholesale, and 1s. 6d. a dozen retail—almost a prohibitive rising market. Since that period oysters have been no less than 2s. 6d. to 3s. 6d. a dozen. No wonder, then, that the formation and protection of oyster-beds should become a subject of grave importance. Mr. Francis Francis informed us in 1865 that "in England, in certain favoured localities, as the eastern coast, companies have had the cultivation of oysters in hand, and are making very handsome revenues from supplying the markets; but they are few, compared with the wide fields which are open to such cultivation. In Ireland the attention of many gentlemen has been particularly turned to this product; and during the year 1860 seventeen gentlemen had obtained licences for the planting of artificial oyster-beds on various parts of the coast. A suitable locality having been chosen and obtained, the cost of planting and preserving an oyster-bed is small, when contrasted with the enormous profits reaped from it, and the subject is well worth the more general attention of proprietors by estuaries, locks, and such localities as are favourable for the planting of oyster-beds. The French are largely engaged in ostreoculture."

This admitted, we will cull a few remarks from the report

on the oyster and mussel fisheries of France, made to the Board of Trade by Mr. H. Cholmondeley Pennell, inspector of oyster fisheries in 1868, and other works and documents which will place our readers in possession of the mode pursued on the Continent in various parts for the cultivation of oysters, etc.

Mr. J. F. Campbell, in his "Life in Normandy," speaks of "oysters in June," and adds, "You always see oysters every market day throughout the year, and I eat them as others do, and find them very good. I suspect that those which are now sold are what are cast up by the tide. The women call them *gite de marée* (oysters of the tide). These may be fish that do not breed, and therefore remain good when others are out of season, for the fishermen do not dredge for them during the summer months; yet the markets are always well supplied with those which the girls collect at low tide on the sands, and, as I have already said, I have always found them very eatable."

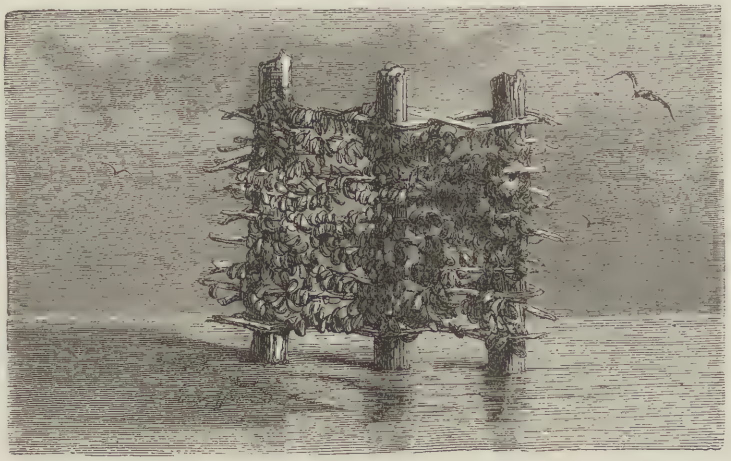


Fig. 33.—MUSSELS FATTENING ON POSTS INTERLACED WITH BOUGHS.

Mussels and Oysters.—It is but twelve years ago that Mr. Cornwall Simeon, in his "Stray Notes on Fishing and Natural History," wrote, "The way in which some of the sea-lochs on the west coast of Scotland teem with animal life is truly marvellous. The shores are in many places literally covered with shell-fish, which are exposed at low water, while the lochs seem to abound with fish almost to an equal extent. The shell-fish mostly consist of oysters, mussels, cockles, and winkles; and when I say that the shores are in parts covered with them, I am not in the least exaggerating the actual fact. I well remember, when I first made acquaintance with that part of the country, my surprise at being shown, in Loch Crenan, a dark-blue bank forming at low water a peninsula perhaps a hundred yards long by some fifty wide; and being told that the colour of this proceeded from mussels, I half thought my informant was joking; but on landing found that he was not only in earnest, but perfectly correct, the whole of it being one mass of mussels (mostly small), lying edgeways, and so densely packed that it would have been apparently a matter of difficulty to insert a pin's point between any two of them. It seemed difficult to comprehend how, under the circumstances, they could manage to open their shells sufficiently for the necessary functions of life. Oysters, too, were numerous; but in consequence of the increased demand for them, they are more sought after than they used to be, and it would not be perhaps now quite so easy to gather a sackfull as it was a few years ago. Vessels also come round occasionally for winkles, and take away cargoes of them to Glasgow; but there are apparently enough to stand such inroads for many a long year to come. On the mussels it would seem that nothing could make the least impression, so vast are the numbers." So much for mussels in Scottish lochs!

Fig. 32.—THE PIROGUE IN USE AT AIGUILLON.

The simple story of the translation of the vast sloughs at Aiguillon into fertile fields of industry, is that an Irish vessel, having been wrecked in the bay, in the year 1235, only one out of all the crew, named Walton, was saved; and he became the founder of the *bouchot* system of mussel cultivation. He at once set about a means of earning his own food, so that he might not be a burden upon the poor fishermen who had rescued him, and who were themselves, at the time, well nigh destitute of every comfort of life. All around him, however, was one vast expanse of liquid mud, and what could any man do on such a barren field? Walton speedily solved the problem. He first of all invented a craft for travelling upon the mud-bed, for walking was an impossibility, as at every step he sank up to his knees in the miry clay. This boat is called a *pirogue* by the boucheliers, and is still in use, by means of which each man, kneeling in his little wooden vessel with one leg—the other being encased in a great boot is fixed deep in the mud—a lift of the little canoe forward with both hands, and a simultaneous shove with the mud-engulfed leg, and lo! a progress of many inches is achieved (Fig. 32). Thus able to get about, Walton plunged a few stakes into the mud, and to these fastened a kind of purse-net to catch some of the vast numbers of birds which assembled there, to satisfy his appetite. It was out of that little example of a destitute sailor's ingenuity that the present industry of Aiguillon was developed, for it was not long before Walton perceived that the strong posts to which he had affixed his net were covered over with the spawn of the edible mussel. These he found grew very rapidly, and when mature, had a much finer flavour than the mud-grown bivalves from whence the spawn had floated. He therefore went on multiplying the stakes, till there was no end to the produce; so that in time this accidental discovery became a rich inheritance to the humane fisher-folks of the district.

Mussel culture is carried to great perfection at Aiguillon, at the port of Esnandes, and Chatellaillon, in France. Aiguillon

is a small bay, about five miles north-west of La Rochelle, the soil of which is mud of great depth and tenacity. The river Sèvre-Niortaise, and two other smaller streams, debouch in the bay. These furnish a great supply of fresh water, highly favourable for mussel cultivation.

The *bouchots* (fishing-hurdles of the mussel-farms, which extend from the lowest mark of spring-tides to within a short distance of high water-mark) are divided into two classes—viz., *bouchots battises*, or those lowest down on the foreshore, and *bouchots d'amont*, situated nearer high water-mark. The former class, which consist simply of rows of posts driven into the mud, are used for breeding purposes—that is, for the young mussel spat to attach itself to. The *bouchots d'amont*, on the contrary, are used solely for the purpose of growing and fattening. They consist of long lines of posts (Fig. 33), like those we have already described, but interlaced with boughs (*clayonnage*), resembling that used in the construction of sheep-hurdles, but coarser, and much less closely woven, perhaps from two to four inches apart. In this *clayonnage* the young mussels are placed, and are secured in the first instance by being rolled up in lumps about the size of a half-quarter loaf, and roughly enveloped in pieces of old netting, which are then thrust in between the interstices of the *clayonnage*. The net becomes rotten in a few months; but in the meantime the mussels have firmly attached themselves by their byssus, so as to withstand the action of the waves. The *bouchots battises* are entirely uncovered by the tides about ten days out of fifteen.

Formerly the *bouchots* were constructed in the form of a V, with the apex pointing seaward; but it was found that in this form they accumulated mud to an inconvenient extent; and recently a great improvement has been introduced by M. Bellenfant, who substituted for the V-shaped *bouchots* long parallel rows of posts, from twenty-five to fifty yards apart, all pointing directly seaward, so that the tide makes a clean sweep of the mud as it advances or recedes. The V-shaped *bouchots* also formerly answered the purpose of *écluses* or weirs.

The posts composing the *bouchots battises*, and also used in the construction of the *bouchots d'amont*, are large and strong, a diameter of half a foot being perhaps the most common thickness. The interlacing boughs average from twelve to eighteen feet in length, and from one to two inches in diameter at the thickest end. A distance of seven-tenths of a mètre, or about 2 feet 3 inches, separates the posts, and a space is left between the bottom of the *clayonnage* and the ground.

The spatting time for mussels is February and March, and by the end of May the young mussel has become the size of a lentil. In July it is as large as a harvest bean, and about this time it is transplanted to the *bouchots d'amont*. After remaining ten or twelve months in the *bouchots d'amont*, the mussel is about an inch and a half in length, and is fit for market. If left longer on the *bouchots d'amont*, they would doubtless increase somewhat in bulk; but at the age at which they are now sold they are smaller than the mussels usually found on the coasts of the British Islands. In the markets of Paris a much larger mussel finds favour, and some of the mussels from the Mediterranean, which are fully three inches in length, command the highest prices. The mussels are sold almost entirely for consumption, and are considered wholesome all through the year; the best two months for them, however, being August and September. The price of a basket of mussels, called a *mannequin*, and containing about 96 pounds, varies from 6s. 8d. to 8s. 4d.

It is a curious fact that, except in very favourable seasons, the young mussels hardly ever attach themselves, in any quantities, to the *clayonnage*, or posts of the *bouchots d'amont*; whilst on the *bouchots battises* they congregate in clusters and layers, one over another, presenting the appearance of swarms of bees. The layers are easily detached by the hand, peeling off with almost the ease and regularity of a roll of cotton-wool, and under one layer may be constantly found a second.

During the winter months the collecting-posts of the *bouchots battises* are all carefully cleaned of the mud, weeds, etc., which they have accumulated, so as to be ready for the next year's spat.

In the bay of Chatellaillon, eight miles from Rochelle, and five from the mouth of the Charente, a large and thriving mussel fishery is also established, the method, soil, and cultivation pursued being in all respects precisely similar to those of Aiguillon.

The value of the produce from the mussel-farms in the quarter of Rochelle was, for the three years 1865, 1866, and 1867, £87,680. All these mussel fisheries—say about 1,400—are believed to be stocked entirely by the natural spat from the coast; and it is not considered possible to form artificial beds, except in spots where there are mussels naturally.

A muddy soil, and the presence of fresh water, are considered essential elements for successful mussel culture. This is the result of the experience both at Aiguillon and other places in France where the experiment has been tried.

The cost of working the mussel farms is estimated at about one-third of the receipts (*vide* Report to Board of Trade, 1868).

Mr. Pennell says, "The mussel-culture of France has now been for many years an established success, and to the pisciculturist is well worthy of admiration." At the same time, he adds, "I fear, however, that at any rate, so far as the coasts of Great Britain are concerned, it is not equally adapted for imitation. There are very few spots round these shores on which the Board of Trade, as guardians of public rights of navigation and anchorage, would probably permit of the construction of such *chevaux de frise* as those, for example, at Aiguillon, or of the artificial creation of submerged rocks, like the stone *écluses* of the Île de Ré.*

"Moreover, the English method of mussel-culture is both simpler and less expensive, and the mussels usually supplied for consumption at Billingsgate and other large markets are cheaper, larger, and better fattened. Billingsgate, for example, draws its principal supplies of English mussels from Essex. These are purchased from Southend, Leigh, South Lynn, the coast of Devon, etc., and are simply laid down on the mud of the foreshore for seven or eight months, usually from January or February to August, when they are fit for market. During May, June, and July mussels are considered unmarketable in England, not having recovered from the effects of spawning. The English mussels are certainly better fished, and more palatable in every respect than those which were examined by Mr. Pennell on the *bouchots*. Considerable mussel supplies are also furnished to Billingsgate from Holland and Belgium.

The price of the English mussels at Billingsgate in 1872 was considerably less than half the price of the Aiguillon mussels, the Dutch and Belgian mussels varying about one-sixth lower than the English.

Mr. Francis Francis, in his "Fish Culture," says, "There are few shell-fish of any kind found upon our coasts, from lobsters to limpets, which are not more or less valuable to some part of our population. Mussels, cockles, shrimps, whelks, and winkles, are all articles of food or commerce, many forming indispensable baits in our more valuable fisheries. Due attention should therefore be paid to their cultivation and supply, as, owing to reckless fishing, some of them have been seriously diminished. A slight notion of their actual value can be formed from the fact that the supply of whelks alone, obtained off the Herne Bay flats (now handed over to a private company), and sold either to the North Sea cod-fishers, or the London market for food, realised something like £15,000 to £20,000 a year, while in many places the sums realised from the sale of mussels would seem incredible. Of anything like the cultivation of lobsters, crabs, and such members of the crustacea, we have so little knowledge, that it may be said to be still an occult or unknown science, though there cannot be a doubt but that artificial

* It is possible, however—nay more, extremely probable—that the mouths of many of our tidal rivers would be found on examination to be admirably adapted for oyster-culture. Some of these estuaries, and notably the large estuary extending from the port of Salcombe, in Devonshire, to the market town of Kingsbridge, about six or seven miles in length, and about the same in width in many parts, seem to be admirably adapted for oyster-culture, and no impediment would be offered to navigation, as the coasting vessels which go up to Kingsbridge are obliged to keep to certain channels between the mud-banks that are visible in all directions at low water. On the Saltstone, a large and broad platform of rock in the lower part of the estuary, might be made excellent collectors for breeding purposes, while oysters might be fattened to perfection on the mud-banks which stretch up to the foreshores. The expense of gathering the oysters would be comparatively small, as it would be done by rakes. The estuary of the Dart, between Dartmouth and Totness, and other similar estuaries, would afford equal facilities for oyster-culture.

means of rearing and feeding them might be easily employed with success. To my knowledge, it has never even been tried. I know but of one small pool, near Titchfield, at the mouth of Southampton Water, where lobsters are placed; and this is a mere stew, in which they are kept for a few days until required. There are, however, numberless places where fortunes could be realised, and vast stores of food provided for the people. In France the practice is followed out to some extent; and at Concarneau, on the coast of Brittany, there are a series of ponds or *viviers* hollowed out of the rock, in which large quantities of crawfish and other fish are raised and nursed for the markets. Such ponds abound around our own coasts, and there is scarcely a harbour or a river's mouth where something of the kind might not, with the utmost ease, be carried out."

At low water, at Boulogne, there were such quantities of mussels near the town, that a cart-load might have been gathered there, and then they would not have been missed.

Oppian speaks of the nacre. This shell-fish is a species of mussel, and furnishes mother-of-pearl. A little fish, of the crab genus, resides within the shell of the nacre, and the above Greek poet treats the connection as a sort of partnership for obtaining food. These mussels were called by the Greeks *pinnæ*, and the small fish that lived in the same domicile *pinnatores* and *pinnophylax*. The nacre, to prevent itself being driven about by the motion of the sea, spins a quantity of long silken fibres, which it attaches to rocks, or any substance—even the sand. These fish are about a foot long, but have sometimes attained the length of two feet. They were formerly much sought after, in order to obtain the silky fibres, which being spun into threads, were manufactured into a variety of articles of dress. The common mussel sends out a number of filaments, and by the observations of Reaumur those filaments are for the same purpose of fixing itself to some solid substance. On opening mussels, a little bunch of green fibres will be seen; these are the parts produced by the fish, whereby it keeps itself upright; and these fibres, if not extracted before the fish be eaten, are very dangerous to the health, because the other portions of the fish easily digest, leaving a mass of these fibrous substances, which are indigestible, to accumulate together by the motion of the stomach, producing in a strong constitution considerable disturbance, and in a person of very delicate habit of body dangerous and even fatal consequences.

Mussels have from time immemorial been a favourite food; but as at some seasons they are very unwholesome, many cases of serious illness, and even of death, have occurred from eating them. "The faculty," Mr. Gwyn Jeffreys observes, "seem to be completely at fault as to the nature of this poison. By some it is attributed to the mussels living among putrescent matters, as in docks, and near the outlets of public sewers; by others to their feeding on the spawn of star-fish, which are well known to be poisonous; by others to their being too freely eaten, and causing a surfeit; or to a morbid state of the system in the persons eating them; by a few to their imbibing into their tissues a solution of copper; and Delle Chiaji showed that in many instances it was owing to these mollusks being at the time in spawn, and therefore out of season. A strange notion once prevailed that the poor little pea-crab was the author of all the mischief."

It is stated that mussels are used at Bideford to fix, by means of their byssus, the stones of a bridge, which is difficult to keep in repair, owing to the rapidity of the tide. The interstices of the bridge are filled with them, and it is said that only their strong threads support the fabric, and prevent it being carried away.

THE LATHE.—XII.

By Henry Northcott.

OTHER TOOLS AND INSTRUMENTS USED BY THE TURNER.

In addition to the tools for cutting the various materials operated upon, other instruments are necessary for holding the work in position attached to the lathe-spindle whilst being rotated and turned, for measuring the dimensions of the article, gauging the depth and angle of the cut, and for various other purposes.

The instruments for fastening the work to the lathe-spindle are mostly known under the name of "chucks." Several of these have already been shown upon the lathes themselves, and it will be seen they are all screwed upon the nose of the lathe-spindle, which should be screwed with a strong coarse-pitched V-thread, rounded well off at both the top and bottom angles, and case-hardened. If the spindle-nose is made too small, it is very apt either to be wrenched off altogether or twisted out of truth by any sudden and exceptional strain; and if it is made too large in diameter, the bosses of the chucks become heavy and clumsy. If the screw-thread upon the spindle be too fine, a very little wear makes a bad fit; and also after using a chuck to carry work from which a heavy cut has to be taken, the chuck is found screwed up so tight against the collar of the lathe-spindle, that some extraordinary means have to be taken to remove it.

In Figs. 7 and 8 (Vol. II., pp. 406, 407) a chuck or driving-plate is shown on the lathe-spindle. This is chiefly used for turning metals, and a piece is shown in place between the centres. At Fig. 11 (Vol. III., page 92) also there are several chucks shown ranged upon the lathe-bed; that one at the extreme right is the face-chuck or face-plate. Fig. 82 is a very useful instrument for driving pieces of wood of small diameter, that can be supported at the other end by the steel centre-point. The shank is made to fit into the hole in the lathe-spindle where the steel centre-point is also fitted. Sometimes this hole is furnished with a screw-thread, and sometimes it is a smooth tapering hole, so the shank of the driving instrument must be made to suit. The central pin of the driver (Fig. 82) should be turned up whilst the driver is in its usual place, as its function is to ensure the centrality of the turned work, although the article may be removed occasionally from its position between the lathe-centres. The two projecting edges of the driver are forced into the wood to be turned, and the deeper they are embedded the heavier is the cut they will stand without slipping round or shearing the wood.

Fig. 83 is a carrier or driver. Its use and position are clearly shown at Figs. 6 (Vol. II., p. 405), 7, 11, etc. The pin at the side of Fig. 84 is for tightening up and slacking back the nipping-screw of the carrier. The driver is chiefly used for metals.

Fig. 84 is a very useful instrument called the "scroll chuck." It is chiefly used for holding round flat pieces of iron or hard woods, which do not require the further support of a centre-point at the right hand. The three jaws may be simultaneously moved either towards or from the centre of the chuck, by means of a spiral or scroll-plate in the body of the instrument, which gears with a kind of spiral rack cut upon the back of the jaws. The body of the chuck is usually made of cast iron, and the jaws of wrought iron case-hardened. The jaws are actuated by means of a box wrench or key, which is inserted in the small recess at the side of the flange. The chief advantage of this chuck is that articles are chucked or fixed concentric at once, without needing any skill on the part of the user, or adjustment of the chuck. They are made in sizes from three inches diameter of flange to about nine inches, but the larger sizes are very heavy instruments. The chuck will receive an article between its jaws of about the same diameter as its flange, but of course a ring of much larger diameter than this can be chucked upon the outside of the jaws.

Fig. 85 shows another variety of the self-centering chuck, designed for holding rod-iron and larger wire whilst it is being turned into screws or other forms. It is also used for holding spiral drills, one of which is shown fastened between the jaws. The key at the side is inserted into the cavity on the edge of the chuck, and twisted round to open or close the jaws.

Fig. 86 is also a self-centering chuck. It is used chiefly for holding small drills as shown. These drills are very efficient instruments, and have come into extensive use in almost every workshop. They will drill through either metals or hard woods; they clear their own holes of shavings, and with fair usage they retain their shape and size until worn out, which is not the case with the ordinary drills. Fig. 87 shows the spiral drill with straight shank, and Fig. 88 with a tapering shank, whilst Fig. 89 is a holder or socket for the drills with tapering shanks.

The wrench or spanner at Fig. 90 is used for fastening the headstock or poppet down on the bed, and for many other purposes. The square at Fig. 91 and the bevel (Fig. 92) are used to determine the angle of one turned surface with another, and the square is also required for adjusting the position of work upon the face-plate and for other work. The standard gauges shown at Fig. 93 are instruments turned to special set sizes, and used in reproducing their own exact diameters. They are

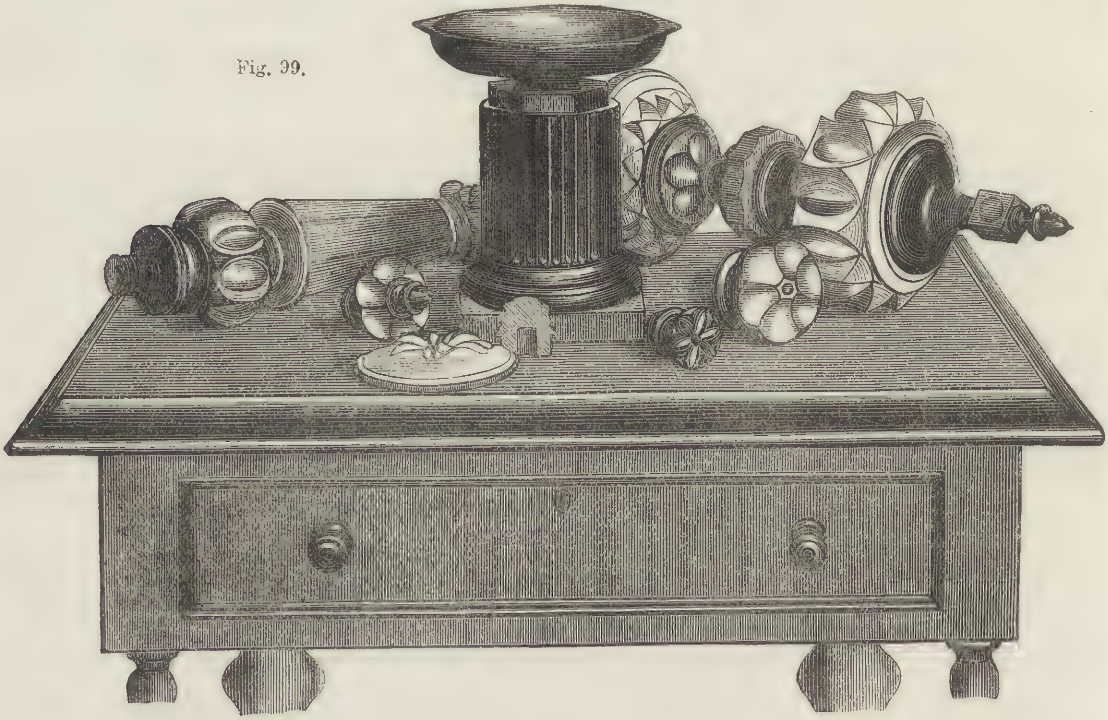
used solely for metal turning. The dividers (Fig. 94) and the compasses (Figs. 95 and 96) are used for finding the centre of the rough materials, for measuring lengths; and the very useful instruments at Figs. 97 and 98 are called "callipers," and are used for measuring the diameters of cylinders and cylindrical holes and other such work.

The articles the hand-turner is called upon to produce are very numerous and various, but amongst them may be mentioned round rulers, tool-handles, cotton-reels, bread-plates, drawer-knobs, egg-cups, chessmen, table-legs, billiard-balls, cubes, pillars, and vases of every shape. Some of these are illustrated in Fig. 99, and although the exact mode of using the tools and executing work can only be learnt by practice, it will be useful to take some of these articles as examples, and explain the various steps a workman would take in producing them.

In turning, say, an ordinary cylindrical ruler, the first thing is to choose the wood. These instruments are generally made of some moderately hard wood, such as mahogany, rosewood, lignum vitæ, or ebony. Most of these woods can be turned with either class of tools, excepting when they are very old and indurated, or of unusually hard quality. The piece of rough wood chosen, if tolerably straight, need be very little larger in diameter than the ruler is to be when finished. It should be cut off rather longer than the complete ruler—say half an inch longer. The projecting corners should be chopped off, and the piece rounded off somewhat if it has been cut from the plank, but if it is a round branch of wood very little need be done to it to prepare it for turning. Loose the tool-rest and the right-hand poppet, and draw the latter along the lathe-bed into such a position that the piece of wood will go conveniently between the lathe-centres. Fix it in this position by tightening up the nut of the headstock. Screw out the cylinder carrying the right-hand centre-point, by turning round the hand-wheel at the right, but only put sufficient pressure upon the screw to hold the wood lightly between the centre and the centre-point of the driver. Apply the flat of the hand lightly to the wood, and draw the hand across the wood so as to move it round. If the wood runs very much *out of truth*, or out of centre, take hold of one end of it, and, keeping it pressed against one centre, slightly remove the other by unscrewing the forcing-screw of the headstock, and then replace the centre against the end of the wood, but in a position rather nearer the side of the wood which appears furthest from the centre. If necessary serve the other end the same. Rotate the wood again a few times, and if it be still out of truth remove the centre-points into fresh positions, and continue doing this until the piece of wood is fairly hung between the two centre-points. When the proper centres have been found in this or other convenient manner, the forcing-screw can be screwed up until the centre-points and the horns of the driver are pressed into the wood deep enough to drive it and support it whilst being turned.

Then adjust the position and height of the tool-rest, bringing the edge of the rest as near the work as it can go without coming in contact with the edges of the wood. It is always advisable to pull round the lathe-spindle once or twice by hand before fastening the tool-rest down, so as to make quite sure that no projecting part of the wood does come against the rest. Fasten down the tool-rest upon the lathe-bed, put a drop of oil about the right-hand centre-point where the wood runs upon it, place the gut on the proper pair of grooves for giving the required speed to the wood as already explained, and set the lathe in motion.

Fig. 99.



The roughing-down tools are then to be applied to the rotating surface of the work, and the whole length of the wood *trued* or *roughed up*. Set the callipers to the size the finished ruler is to be, and with the finishing tools remove the rough lines left by the other tools, and carefully take off sufficient material—and only sufficient—to enable the callipers to go easily astride the ruler in every place. As before observed, nearly the whole of the material should be removed with the roughing tools, and only enough left to allow of rough lines being obliterated by the sharp finishing tools. In turning a long cylinder, whether in wood or iron, it is generally a good plan to turn down a series of bands all along the work to the required size, as these bands then guide the turner in turning the remainder of the cylinder. The surface of a ruler has, of course, to be very smooth and straight. The edge of a square or of a thin blade of steel made straight for the purpose, and called a "straight-edge," is occasionally placed along the upper part of the cylinder, so that by looking between the two edges in contact the turner may judge of the parallelism of his work. When the ruler is nicely turned upon its face, its ends are rounded off with the suitable side-tools, and the whole may be rubbed over with a

piece of old glass-cloth, or a handful of the fine shavings that have been turned off. Either may be moistened with a few drops of oil, and held against the wood whilst it is running. This brightens the surface and brings up its grain.

In turning up a surface—say a bread-platter—the wood is cut from a plank, and if the wood is valuable it is cut round at once with a sweep-cutting saw; but if cut out square, and the wood is not very valuable, the corners must nevertheless be cut off, and the wood rounded as much as possible before it goes to the lathe. This is advisable because, whereas such corners can very easily be rounded off with a small saw, they are rather awkward to deal with when running round in the lathe. They are apt to knock an inexpert workman's tools out of his hands, to break the screw or other chuck to which the wood is fastened, to cause the wood to split, and also to absorb a good deal of power, as the turner soon finds out if the work be attempted on a foot-lathe. When the flat piece of wood is prepared, it is fastened to the lathe-spindle by means of a suitable chuck or face-plate, and is turned up roughly as in the last example. The right-hand poppet is not required for this kind of work, and it should be pushed back out of the way; and as the speed for this work or the edges of it will be comparatively low, the gut-band should be shifted into the largest of the lathe-spindle pulleys. The best plan, generally, is to turn one surface smooth and to the proper shape, complete, and then to turn it over and chuck it upon the finished side, taking care that the work beds fairly against the surface of the chuck, so that the one part may be true with the other. For flat articles which do not admit of having holes made in them, the usual mode of chucking is by means of a composition called Turner's Cement. Any flat chuck of suitable diameter is warmed, and a piece of cement rubbed over its face, and the article to be chucked is pressed well down upon the cement. When the chuck cools the wood is firmly cemented to it, and with care a fair-sized cut may be removed without detaching the work from its chuck. After the article is finished, it is removed by a slight tap with a hammer. In using the cement it is always advisable to have a fairly true surface to come against the chuck; and it is sometimes necessary to plane up the rough wood, in order to obtain one. But, as a rule, a little time spent in preparing work for chucking saves a good deal of time and trouble when turning it. It must always be borne in mind that the thinner the coating of cement between the chuck and the article, the less is the likelihood of the finished work being out of truth, as it is difficult to ensure a perfectly even coating of the cement upon the entire surface of the chuck. And it is a mistake to imagine that the holding power of the cement is increased by its being laid on thickly.

To turn a perfect cube in the lathe would appear at first sight an impossibility; but in reality this is a most simple form to produce—much more so than the sphere. The cube is a six-sided solid, and all its sides are plane surfaces. We already know that it is as easy to turn a plane surface in the lathe as to turn a cylinder, and to produce a cube it is only necessary to turn six plane surfaces in certain positions, the one with the other. The turner would proceed as follows:—He would first take a piece of wood sufficiently large to enable him to turn a cylinder out of it, with a diameter equal to the diagonal of the square side of the cube. And this also he would do, cutting the cylinder off to a length equal to the side of the square. This would then show a short cylinder with two flat ends, or a thick flat disc, and this disc would be placed in a chuck in a position at right angles to the position in which it was turned; that is to say, the axis of the cylinder is placed parallel to the surface of the chuck; and the lathe being set in motion, a third surface is turned upon the article, which is then removed from the chuck, and replaced with this third flat surface bearing against the surface of the chuck. In this

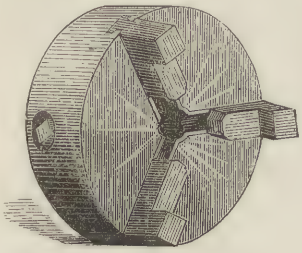


Fig. 84.—SCROLL CHUCK.

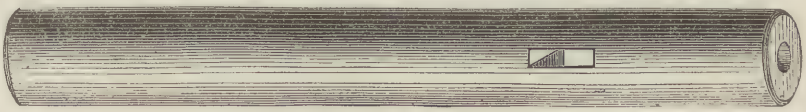


Fig. 89.—SOCKET FOR DRILLS.


Fig. 88.—TAPER-SHANK DRILL.


Fig. 87.—STRAIGHT-SHANK DRILL.

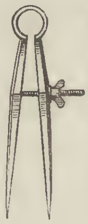
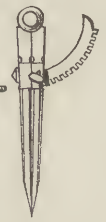




Fig. 96. Fig. 94. Fig. 95.


Fig. 97.

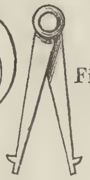


Fig. 98.


Fig. 91.

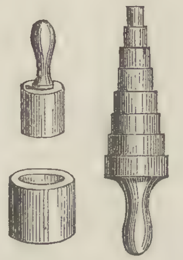


Fig. 93.—STANDARD GAUGES.

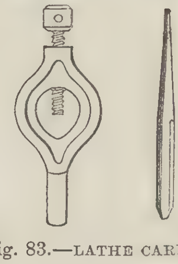


Fig. 83.—LATHE CARRIER.

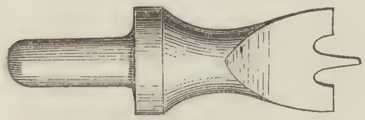


Fig. 82.


Fig. 92.

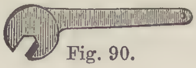


Fig. 90.

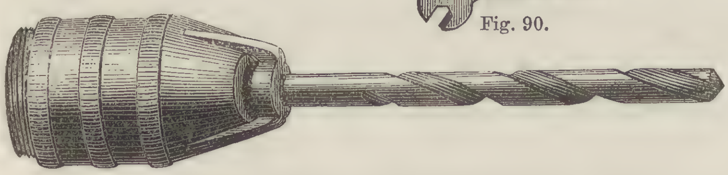


Fig. 86.—UNIVERSAL CHUCK, WITH A STRAIGHT-SHANK DRILL.

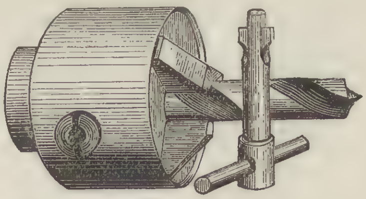


Fig. 85.—SELF-CENTERING CHUCK.

position a fourth flat surface can be turned upon the article, and if the settings have been carefully made, these two last surfaces revolve at right angles to the two forming the ends of the cylinder. Two further similar settings of the work in the chuck will enable two other surfaces to be turned, and these will complete the cube.

There is no difficulty in producing a solid of any other number of sides. The production of the cube is more of a puzzle than a difficulty, because knowing the mode of its production removes the difficulty. To produce a perfect sphere, however, requires somewhat more address and skill on the part of the workman. Turners who are in the habit of producing billiard-balls and other spheres in large numbers become wonderfully quick and exact; but the beginner may generally expect a slight trial of his patience, and the exhibition of a good many balls anything but perfect spheres, before he succeeds satisfactorily. The best method of turning spheres by hand is as follows:—Take a piece of wood of the required size, and turn out a short cylinder in the same way as in the last example. Let the diameter of the cylinder be equal to the diameter of the required sphere, and let the length of the cylinder be the same as its diameter. Chuck this short cylinder in the same position as in the last example, with its axis parallel to the surface of the chuck, taking care to so adjust it upon the chuck as to let the axis of the lathe's rotation pass through the middle of the cylinder both lengthwise and crosswise. It is always a good plan to divide the cylinder accurately into two by a very light line around it before cutting it off. The lightest touch with a sharp point will be sufficient. When the work is properly chucked the lathe is set in motion, and some sharp tools are carefully applied to round off the projecting parts and produce one half the sphere. In doing this, as the outline of the cylinder will in rotating describe a sphere, this outline acts as a very efficient guide, and the workman removes all the material lying outside the imaginary sphere so described. The reader may have some difficulty in understanding this clearly, but he will probably see it better when he puts the instructions into practice.

One half of the sphere being formed, it only remains to reverse it and form the other half in the same way.

Fig. 99 represents a group of articles exhibited at a recent competition of the London Turners' Company. The central object is a tazza, and was exhibited by Mr. Edwin Baker, who also turned the two small objects shown in front of the tazza, and the small articles shown in it. None of these, however, were exhibited. The other objects were all exhibited by Mr. Battersbie, and are all turned in a very plain foot-lathe, and with the plainest of tools.

The cup of the tazza is made of Cannel coal, and the column and base are of African blackwood. The edge and the foot of the cup are octagonal, and these flat sides are cut by hand, not in the lathe. They can be produced in the lathe, but to do so requires apparatus of a different kind to what has yet been described. The flutings are also made with special instruments, but these belong to a more advanced stage of the art of turning. The column has thirty-two flutings, and its base is square, with a side of four and a half inches. The entire height is six and a half inches. Cannel coal, of which the cup is formed, is a very dirty material to work. It is brittle, and comes away in small dust and chips, but receives a very fine polish when properly turned. The tools necessary for this material are ground with an obtuse cutting angle, much the same as that used for hardwood turning. The wood known as African blackwood is a very fine wood. It turns well, and is capable of receiving a first-rate polish.

The object in front is a profile head. The wood is turned into such a shape that its section shows a man's head. Readers are doubtless familiar with a head of Wellington cut in this fashion. A similar system of profile turning is used to produce the toy animals in Noah's-arks. They are first turned in rings to a certain section, then cut into slices, and carved into shape. The other articles are made of mahogany, boxwood, and black ebony. The forms are produced in the usual way, and the ornamentation is effected by separate chuckings of the work, so as to present it to the tool in various positions, in much the same manner as when producing the cube. But very much larger chucks are necessary for this kind of work than for ordinary turning.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIX.—SIR JOHN LESLIE, K.H., F.R.S.E.

BY JAMES GRANT.

Sir John Leslie, so distinguished for his discoveries and writings, the inventor of the hygrometer, by which water and mercury may be converted into ice, and the inventor of the differential thermometer, was born at the picturesque little village of Largo, in Fifeshire, on the 16th of April, 1766. He was the son of a poor joiner, named Robert Leslie, and of Anne Carstairs, his wife, a native of Largo. His father came originally from St. Andrews, and though poor his means and humble his occupation, in point of education and attainments he was far above the people of his station.

The education of his son was necessarily scanty at first, being obtained first at the school kept by an old woman in the village, and afterwards at another at Lundin Mill, and thirdly, in the village of Leven, where he attended only six weeks. There, however, the barefooted and poorly-clad little boy obtained the first rudiments of Latin, and while at home received some lessons in mathematics from his elder brother Alexander. Before he had reached his twelfth year he attracted considerable notice by his extraordinary proficiency in geometrical exercises, and he became known to Professor Robison, of the University of Edinburgh, and through him to Professors Playfair and Dugald Stewart, at whose suggestion his parents, though but ill able to afford the expense, inspired by that desire, so honourable in the Scottish poor, to educate and raise their children above themselves, sent him to the University of St. Andrews, with the view of educating him for one of the learned professions. This was in 1779.

At the first distribution of prizes his abilities introduced him to the patronage of Robert Earl of Kinnoul, then Chancellor of the University. Being destined for the Church of Scotland, he went through the regular routine of instructions for that purpose. After attending for six sessions at St. Andrews, he removed to Edinburgh, in company with another youth—destined like himself to obtain a niche in the temple of fame—James (afterwards Sir James) Ivory. Three years' more study followed at the old Academy of James VI., where he obtained an introduction to the celebrated Dr. Adam Smith, who employed him in assisting the studies of his nephew, Mr. Douglas, the future Lord Reston; and he now gave up all idea of adopting the Church as a profession, as he found it altogether incompatible with the strong turn which his mind had taken towards physical studies.

On being appointed tutor to two young college friends, named Randolph, who were natives of Virginia, he accompanied them there in 1788, and was absent a year, during which he visited New York, Philadelphia, and other transatlantic towns. In 1790 he proceeded to London, with letters of recommendation from several literary and scientific men, of whom there were no lack then in the Scottish capital, and among others from Dr. Adam Smith, who told him, at parting, that "if the person to whom he was to present himself was an author, to be sure and read his book before doing so, that he might be able *to speak of it*, should occasion offer."

Young Leslie's first intention was to deliver lectures on natural philosophy; but finding, to use his own words, that "rational lectures would not succeed," he had recourse to his pen as the most ready means of support, and began to contribute articles for *The Monthly Review*. About the same time he was employed by an old fellow-student, Dr. William Thompson, the continuator of Watson's "Reign of Philip III. of Spain," to furnish notes for an annotated edition of the Bible (then publishing in numbers), which he did under the name of Harrison. By Murray, the bookseller, he was next employed to translate Buffon's "Natural History of Birds," published in nine volumes in 1793, and the payment for this, with his prudent habits, laid the foundation of his subsequent independence.

While this work was in progress, he fulfilled an engagement with the Messrs. Wedgwood, of Etruria, in Staffordshire, to superintend their studies. He left them in 1792, and two years later he visited Holland. In 1796 he made the tour of Germany and Switzerland with Mr. Thomas Wedgwood, whose untimely demise he ever mourned as a loss to science and his country.

Previous to 1800 he had invented the differential thermometer, which is described as "one of the most beautiful and delicate instruments that inductive genius ever contrived as a help to experimental research; and the result of his inquiries concerning the nature and laws of heat, in which he was so much aided by this exquisite instrument, was published in 1804." This was his celebrated "Essay on the Nature and Propagation of Heat." Though defective in method, somewhat questionable in theory, and indifferent in style, its striking discoveries and experimental devices more than atoned for all its faults.

On the promotion of Professor Playfair from the chair of Mathematics to that of Natural Philosophy in the University of Edinburgh, Mr. Leslie offered himself as a candidate for the vacant professorship; but his election was vehemently opposed by the moderate party among the city clergy, who were desirous of placing one of their own body, Dr. Thomas MacKnight, in the chair. They grounded their objection to Mr. Leslie upon a note to his Essay on Heat, which referred to Hume's theory of causation; and hence they deemed it of an infidel nature and tendency.

Keen discussions followed in the ecclesiastical courts; but in these Mr. Leslie was stoutly defended by Sir Henry Moncrieff, the case was dismissed by the General Assembly, and in consequence, he entered, without further opposition, on the duties of his chair. Previous to this period, and when not otherwise engaged, he was wont to live with his brothers in his native village of Largo, where originally all the experiments for his "Essay on Heat" were carried on, and where the book itself was written.

Through the assistance of one of his many ingenious contrivances—his hygrometer—he arrived, in 1810, at the discovery of that singularly beautiful process of artificial congelation, which enabled him to convert water and mercury into ice. In the *Scots' Magazine* for that year there is a description of the process, which then greatly excited the attention of the public. A brother professor writes thus:—"We happened to witness the consummation of the discovery—at least the performance of one of the first successful repetitions of the process by which it was effected; and we shall never forget the joy and elation which beamed on the face of the discoverer as, with his characteristic good nature, he patiently explained the steps by which he had been led to it."

In the preceding year he had published his "Elements of Geometry," which immediately took its place as a class-book, and has since gone through several editions. In 1813 appeared his "Account of Experiments and Instruments, depending on the relation of Air to Heat and Moisture;" and in 1817 he printed his "Philosophy of Arithmetic, exhibiting a Progressive View of the Theory and Progress of Calculation." In 1821 his "Geometrical Analysis" appeared, and in the subsequent year his "Elements of Natural Philosophy," for the use of his class. A small octavo, published in 1828, entitled "Rudiments of Geometry," designed for popular use, was his last separate work; but he was author of many excellent articles in the *Edinburgh Review*, then in the zenith of its fame; of three profound treatises in "Nicholson's Philosophical Journal;" a few in the "Transactions" of the Royal Society of Edinburgh; and of several valuable articles in the supplement to the "Encyclopædia Britannica."

In 1819, on the death of Professor John Playfair, whose promotion had formerly made room for him in the chair of Mathematics, he was elevated to the professorship of Natural Philosophy. By this the great powers of his mind had a wider field for display and use than they had possessed for the fourteen preceding years.

Among the preliminary treatises of the seventh edition of the "Encyclopædia Britannica," which began to appear in 1830, he wrote one on "The History of Mathematical and Physical Science during the Eighteenth Century," which attracted great attention from its agreeable and masterly style.

On the recommendation of Henry Lord Brougham, then Chancellor, he was invested with the Knighthood of the Guelphic or Hanoverian Order, at the same time that Herschel, Charles Bell, Ivory, Brewster, South, and Harris Nicolas received a similar mark of distinction; but he was not destined long to enjoy the honour conferred upon him. The income he enjoyed for many years was far above his necessities, and thus, in time, he amassed the sum of £10,000. In his latter days he expended the most of this in the purchase and decoration of a mansion, called "The Coates," near his native village in Fifeshire, where he spent all the time he could spare from his duties at the University. But in the end this proved a fatal acquisition.

In the October of 1832, while superintending some of the improvements at Coates, by incautious exposure, he caught a severe cold. Among the few foibles he possessed was a singular contempt for medicine, and an unwillingness to believe that he would ever be seriously ill. Hence he neglected an ailment that at first was slight, but he was soon seized by a disorder, at that time very prevalent in Scotland—erysipelas in one of his legs. On the 31st of the same month he was rash enough to expose himself again. The fatal malady rapidly advanced, and on the evening of Saturday, the 3rd of November, 1832, he expired, in the sixty-sixth year of his age.

The person of Sir John Leslie, especially in his later years, has been described as being far from gainly. "He was short and corpulent, with a florid face and somewhat unsightly projection of the front teeth, and he tottered considerably in walking. He was, moreover, very slovenly in his mode of dressing—a peculiarity the more curious, as it was accompanied by no inconsiderable share of self-respect, and an anxiety to be thought young and engaging. The mixture of great intellectual powers with the humbler weaknesses of human nature can seldom have been more strikingly exemplified than in his case; though it is evident that, as his weaknesses were very much those to which unmarried men in advanced life are supposed to be peculiarly liable, "that might have been," says Robert Chambers, "obviated in a great measure if he had happened to spend his life in the more fortunate condition of matrimony."

One of his little vanities was to have his hair dyed; but unfortunately the colours often varied or refused to mingle. He was, however, the most placable of human beings, was a kind friend, a tender relation, and good man in all his ways of life. "There is one other matter," says Macvey Napier, "which, in justice to the illustrious dead, we cannot pass over in silence. We mean the permanent service rendered to the class of natural philosophy by the late Sir John Leslie, in the collection of by far the finest and most complete set of apparatus in the kingdom." Among the many monuments erected to eminent men in Scotland there has been none as yet raised to Leslie.

INDIAN RUBBER.—IV.

By George Gladstone, F.C.S.

ELASTIC WEBS—EFFECT OF GREASE—OF SUNLIGHT—TELEGRAPHY—VULCANISATION—ITS IMPORTANCE—HOW PRODUCED.

The threads, the cutting of which was described in the last article, are used in the weaving of webs which shall be elastic in character. The very elasticity of the material, however, rendered it difficult at first to produce an article which should lie flat, because if one thread was stretched more than another in the loom, it would, when taken out, cause the web to contract unevenly.

Prior to the weaving, the threads are stretched to the full, and then rendered inelastic, so that they can be manipulated like any other article. The stretching is accomplished by first heating them in warm water, which increases their elasticity, so that they can be drawn out to seven or eight times their natural length, which is done by the tenter boy or girl through whose finger and thumb each thread is drawn as it is wound upon a reel. In the process of extension a great deal more heat is developed, so much so as to be exceedingly uncomfortable to unpractised hands; the effect upon the Indian rubber appears to be very similar to that upon metals in wire-drawing, as they also become heated and hardened under the operation, and have to be subsequently annealed to regain their tenacity. The threads are left upon the reels, and thoroughly cooled for several days before use, by which time they will have quite lost their elasticity.

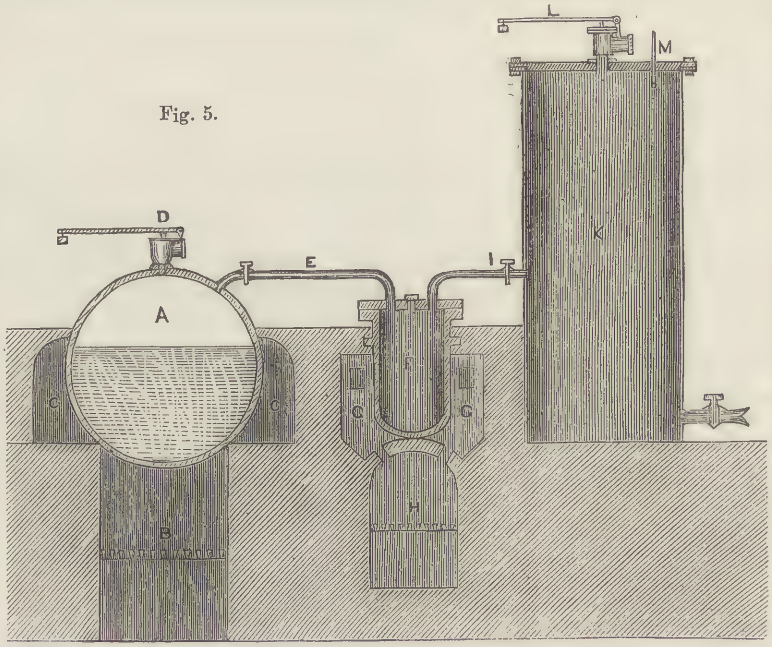
The filaments of rubber form the warp of the elastic band, or the foundation of the braid, and are worked up with silk, cotton, or other thread in riband looms or braiding machines. On the fabric being completed, the Indian rubber threads are

again rendered elastic by the application of a moderate heat, say about 150° Fahrenheit. This is usually done by passing a heated iron or roller over the articles, when the fabric contracts, and draws all the threads very closely together. If it is intended to produce a pattern upon the goods, an allowance is made for the amount of subsequent shrinking, so that the design may ultimately appear in its proper proportions; some articles, however, are always slightly stretched when in use, which forms a second element in the calculation when laying out the pattern for such goods.

All kinds of grease exercise a deleterious effect upon caoutchouc, destroying its elasticity, and reducing it to a sticky pasty condition; and articles such as those above described should not be worn near the skin, as the products of transpiration are always of a more or less oily nature; but where sufficiently protected by under-clothing, elastic bands and braids are of the greatest convenience as articles of dress, and there is an enormous and constant sale for them.

Indian rubber is also deprived of its most important qualities by a prolonged exposure to sunlight, especially when in a dry state. This appears to be the result of a gradual oxidation of the article, which converts it into a soft, sticky, resinous mass. Five hundred grains of virgin caoutchouc, cut into the form of a tape, after being exposed in a bottle with the mouth downwards, increased in weight fourteen grains in the course of nine months "by absorption of oxygen, and had become brown, soft, and sticky, especially in those parts most exposed to light. It gave up 11·81 per cent. of an oxidised, soft, and viscous resin to alcohol." The analysis of the resin was as follows:

Fig. 5.



Carbon	67·23
Hydrogen	9·54
Oxygen	23·23
	100·00

Similar samples exposed to diffused light for the same period under fresh and salt water absorbed a certain amount of moisture, but were not altered in chemical composition, nor had lost any of their original properties. The action of the sunlight upon masticated rubber was even more strong, the tape exposed only to diffused light being reduced to a viscous lump yielding to alcohol 12·64 per cent. of resin, while a similar one kept in the dark yielded only 2 per cent. of resin, and was not affected in its tenacity and elasticity. A similar piece of masticated rubber immersed in fresh water, open to the air and diffused light, gained 87 per cent. in weight, and had lost all its valuable properties; while another similarly exposed to the light and air under sea-water only gained 5 per cent. in weight, and had become slimy merely to a slight degree. Though anticipating the whole subject of the vulcanisation of rubber, it may be as well to add here, that experiments made at the same time upon the vulcanised article show—"1st. The sheet exposed in the netting to the sun and rain had lost 2 per cent. in weight: it was scarcely less tenacious than at first. 2nd. A similar sheet in fresh water absorbed 19 per cent., but was not otherwise altered. 3rd. A similar sheet in sea-water was rather more slimy, and had only gained 1·6 per cent. in weight." These experiments were made by order of the Committee of the Privy Council for Trade and the Atlantic Telegraph Company, as being a matter of national interest since the laying of deep-sea cables has been achieved.

This naturally leads us to consider the application of caoutchouc to submarine telegraphy. It has been already mentioned that it is a non-conductor of electricity, as well as impervious to water, especially when salt, so that it possesses the very qualities required in an insulator for a wire which has to be submerged at the bottom of the sea. It may perhaps, however, be scarcely equal as an insulator to gutta-percha and some patented preparations, when subjected to great pressure—more particularly is this the case if the rubber has previously undergone mastication. The process of coating the telegraph wire usually consists in cutting the material into long tapes, winding them round the wires, and consolidating them either by heat or the use of solvents. These make a perfect join for a time; but it not unfrequently happens that after a while indications become apparent of the insulation becoming imperfect, which of course impedes and ultimately prevents the passage of the signals.

Useful as caoutchouc is in its natural state, it has been rendered ten times more so by the discovery that at certain temperatures it will combine with sulphur, and yield an article which shall possess its most important properties in an increased degree, and at the same time be deprived of some of those which limited the applications of the original substance. The transformation thus caused is now known by the name of vulcanisation.

This process was discovered about the year 1843, in which it was patented by Mr. Hancock. The American manufacturers claim, however, to have made and used the vulcanised rubber at a prior date, but they did not patent it till subsequently, and that of Hancock was held valid in our law-courts when the questions of originality and prior publication were raised. The original patent rights are now, however, mere matters of history, as they have expired by efflux of time, and the trade is therefore quite open as far as they are concerned.

The first vulcanised rubber was made by melting a quantity of sulphur in an iron pot, and dipping pieces of the pure article into this bath until they had become permeated by the sulphur to their centre. When this step of the process was complete was ascertained by cutting the pieces open, as the sulphur deprives the rubber of its dark colour. The temperature of the bath was then raised to 270° or 280°, and after about an hour's exposure to this increased heat the vulcanisation was effected. In such primitive apparatus as was used at first the temperature of the bath could not be regulated with any great nicety; the sulphur near the bottom of the pot was of course much hotter than that at the surface, and so the pieces of caoutchouc which were lowest were exposed to greater heat than those above. This was found to lead to very different results, and showed that the character of the product could be completely altered by the use of a greater or less amount of heat. Thus, while the upper portions of the vulcanised rubber were pliable and highly elastic, the lower were converted into a hard, horny substance, only slightly plaible, and altogether devoid of elasticity.

In manufacturing the article for use, it is necessary, therefore, to be able to regulate the temperature to a nicety, and to have it distributed equally throughout the bath, so that the workman may ensure a certain result and a uniformity of character throughout the entire piece of material. A very convenient arrangement has been adopted at some works for using high-pressure steam as the heating power, by which means the temperature throughout the vulcanising chamber will be uniform, and can be regulated with the greatest precision.

Fig. 5 will show how the operation is conducted by means of steam. A represents the cross section of a boiler set over the fire-place B, the flues from which, C C, traverse it on both sides. At D is the safety-valve, and at E a pipe furnished with a stop-cock leads from the boiler to a small vessel F, which contains the sulphur or sulphurous ingredients. This is heated by the flues G G, which pass from a second fire-place situated below at H. A second pipe, I, similarly furnished with a stop-cock, communicates between this vessel and the large one, K, in which the caoutchouc to be operated upon is placed. This receiver is also provided with a safety-valve, L; a thermometer, M, for watching the temperature; and at the bottom a tap for drawing off the condensed vapour. Steam having been got up in the usual way, the pressure upon the valve D is so adjusted as to raise the steam to a temperature of 270° Fahrenheit, or such other as may be required. As soon as that is indicated, the fire at H is lighted in order to volatilise the sulphur contained in the vessel F. The stop-cocks in the two connecting pipes E and I are then turned on in succession, the caoutchouc to be vulcanised being already placed in the receiver K, so that the sulphurous vapours evolved in the vessel F are carried forward by the steam admitted from the boiler into the ultimate receptacle. At first the steam which passes into K is almost pure, and this serves to warm up the receiver and its contents to the required temperature; but as the sulphur vapours begin to be evolved in the vessel F, they of course pass on with the steam and envelope the caoutchouc. The thermometer in the top plate of the receiver will show whether the temperature desired is maintained throughout the operation; and if it should show signs of falling, it can be at once adjusted by increasing the pressure on the valve D, or *vice versâ;* and after a period varying usually from half an hour to two hours, according to the thickness of the material operated upon, and the degree of vulcanisation which is desired to be given, the conversion of the rubber will be complete, and the operation is stopped. The fires are then withdrawn, the stop-cock closed, and the steam let off through the safety-valves, after which the vulcanised rubber is taken out of its receptacle.

In this process heat and time are, to a certain extent, interchangeable commodities. Thus, to adopt the words of Mr. Hancock's own patent, "If sheet caoutchouc one-sixteenth of an inch thick is continued in sulphur at 350° to 370° from ten to fifteen minutes, the change before alluded to is produced; or, instead of so high a temperature, the sulphur is raised only from 310° to 320°, and the caoutchouc immersed in it from fifty to sixty minutes, the result will be much the same; and if continued for two hours at the same temperature, the effect will be proportionally increased; and if continued longer, the caoutchouc becomes of a darker colour, and nearly loses its property of stretching; and if carried still further, turns nearly black, and has something the appearance of horn, and may be pared with a knife similarly to that substance."

The sulphur may be applied in various other ways than those already described. It may be blended mechanically with the caoutchouc by working them up together in the masticator, the sulphur being first finely powdered; the heat evolved in the course of the mastication will suffice to produce the required change; or it may be done by dissolving up the sulphur in one of the solvents of Indian rubber, such as boiling oil of turpentine, and then treating the rubber with just so much of this compound as will impart to it the requisite amount of sulphur in the subsequent evaporation of the oil.

ENGLISH CARRIAGE-BUILDING.—III.

BY A LONDON COACH-BUILDER.

SPRINGS AND THEIR OFFICE—WHEELS—METHOD OF MAKING WHEELS—PUTTING ON AND VARNISHING LEATHER—FIRST STEPS IN COACH-PAINTING.

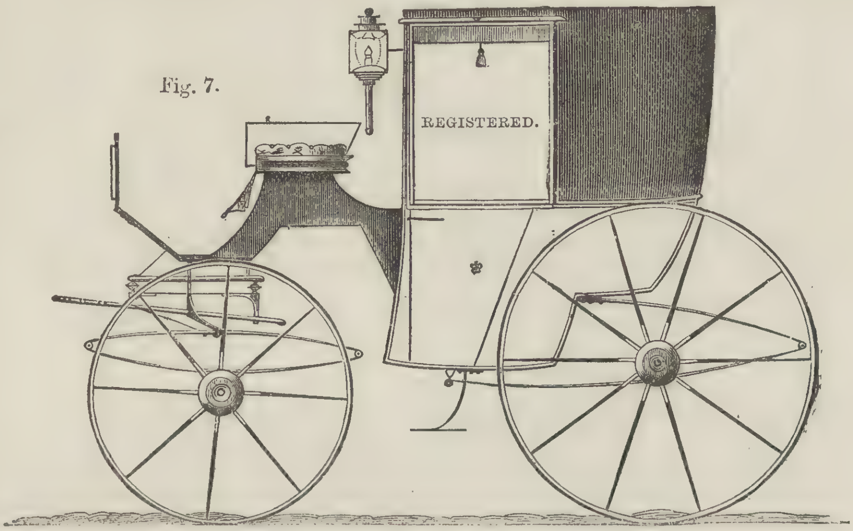


Fig. 7.

If the body of a vehicle be mounted upon the carriage without springs, it will require a greater power to draw it than if the springs were added. The load which the body constitutes is a mere dead weight, the tendency of which is to remain motionless, and therefore to resist the power that draws it. This would be particularly experienced on a rough road, or in ascending an incline, for, wherever an obstacle presents itself, the power of this *vis inertia* becomes greater. After a carriage has been once set in motion upon a smooth and level road with any given velocity, its motion, so long as that velocity is continued, will neither be retarded nor promoted by its *vis inertia;* but whenever it passes over any height, not only the weight of the carriage must be lifted, but the *vis inertia* of that weight in a new direction must be overcome. Now, by placing springs beneath the load, it becomes, as it were, quickened into life and activity, and has a tendency partially to assist instead of entirely to resist the motive power that draws it.

If this fact were fully recognised, it would be seen how great is the necessity of giving to the springs of a carriage the maximum amount of elasticity, and far more attention would be paid to that part of carriage-building than it receives at present. But what we have said is sufficient to show the vast necessity of using the best steel for the manufacture of springs, and we know of no better than that which issues from the firm of Messrs. Oxley, of Rotherham, a firm which is well known throughout the carriage trade of England.

The spring in general use for pleasure carriages is elliptical in form, and consists of several plates, the number varying according to the substance of the steel and the strength required. The plates are fitted to each other, and being forged to the required span are held in position by studs. Each plate should fit exactly to the other, and the whole when together should present a graceful sweep, at once pleasing to the eye, and perfect in form.

It might appear to the uninitiated that all this could be done

by the ordinary smith, but spring-making is a separate and distinct branch of industry, and requires great skill in the process of forging and fitting, and more especially in the process of hardening. For this purpose a peculiar fire has to be made, in which each plate has to be heated to one regular heat from end to end, after which it has to be plunged into a cold bath, and the experienced eye of the spring-maker detects, in the manner of cooling, whether the steel is properly tempered or not. If the steel be rendered either too hard or too soft, a great deal of its elasticity will be destroyed.

The wheels should be made with a due regard to the duties and offices they have to fulfil; but we are inclined to think that very little thought has been devoted to this branch of industry. The original idea of a wheel was that of the roller, whereon to place heavy loads, to facilitate their movement from place to place. Mechanical genius of the time of the Pharaohs saw the advantage of lightening out the mass, and produced a piece of mechanism circular in formation, which was supported by struts radiating from a central block. This was the first form of a framed wheel, and it has undergone slight modification; the wheel of modern days is the same in principle, but less clumsy in appearance. The mode of constructing it is as follows:—

First, the timbers should be well and carefully selected, the stock or hub, which is sliced from the limb or trunk of the tree, should be in growth as near as possible the size required, needing little reduction beyond that which it will receive in the turning-lathe. The object of this is that the rings which mark the grain of the timber should be as unbroken as possible; for a similar reason the spokes should be cleft, because in splitting, the grain must be followed, whereas, if the spokes were sawn out, there would be the fear of sawing across the grain; the felloes which form the outer periphery should also be cut as near as possible with the grain of the wood.

When the wheelwright has thus selected his timbers, he commences work with the stock, which is turned to the proper size and shape; round this he describes four rings, with a gauge answering to the width of the spokes—the first and the third rings mark the positions of the face spoke, and the second and fourth rings the positions of the back spoke; between these lines he alternately cuts the mortises to receive the ends of the face and the back spokes, twelve or fourteen in number, according to the height of the wheel; the spokes are then shouldered down slightly taper-wise, that is, the part that is to be driven into the stock is cut at the end the same size as the mortise-hole, and tapers to about one-sixteenth of an inch wider on each side at the shoulder. When all this is prepared, the spokes are driven home to a perfectly close bearing of the shoulder, or to the stock, the length of the spokes is then gauged, and the ends that enter the felloes are tongued. In the manner of tonguing spokes there is a good deal of difference of opinion among wheelwrights; that the tongue in size should be slightly in excess of the hole in the felloe that receives it, most are agreed, but a difference of opinion exists as to length.

One of the difficulties in making light carriage-wheels is to get the spoke to fit tightly into the felloe without splitting it; and the manner of accomplishing this is not by making the tongue of the spoke so large that of itself it will hold tight in the felloe, but by slitting the end of the tongue after the felloe is drawn on to it, and wedging it up. To effect this properly, some wheelwrights will say that the tongue of the spoke should be cut longer than the depth of the felloe, from inside to out, others that it should be cut slightly shorter. To us it appears of very little consequence one way or the other, so long as the end of the spoke be not allowed to project beyond the outside of the felloe. After it is made and ready for the tire, there should indeed be a little clearance between the end of the spoke and the outer surface of the felloe, for when the tire comes to be put on it draws all the felloes up into their proper position, and if in doing so it should press on the end of the spoke, the spoke will most likely be crippled.

When the wheel is so far progressed with, it is laid on the ground, and the felloes ranged round it in the order in which they are to be fitted. It is of the greatest importance that the holes be bored in the felloes to receive the spokes so as to range in an exact straight line with the mortise-hole in the stock; if it does not, the spoke will have to be strained out of the straight line in order to get it into its position; this will put an undue pressure upon it, and in all probability the wheel will not be long in wear before that spoke breaks off short in the felloe. The exact position of the hole in the felloe must therefore be obtained, and it must also be bored perfectly true to the line represented by the spoke. As the wheel is constructed very much on the principle of the arch, it is considered that by giving a number of joints to the outer rim, its strength is increased, and the number of felloes which form this rim is decided by the weight of the wheel. For a brougham the felloes of the hind wheels should be seven in number, and for the front ones six, and each felloe should be bored to receive two spokes. To connect the felloes with each other, a dowel or pin is cut at one end of each felloe, and a hole bored at the other, the pin at the end of one felloe being made to fit in the hole at the end of the other. In badly-constructed wheels the ends of the felloes are simply bored, and the pins that hold them together are driven in in the form of plugs. This process involves less time and trouble than cutting down the end of the felloe so as to have the pin in the solid with it, but the felloes of a wheel so put together will soon discover their weakness by slipping out of their true position, or what is technically called *dropping*, yet this dropping of the felloes will equally take place when the pins are cut in the solid, if they do not fit tightly and perfectly in the holes bored to receive them.

When the wheel is framed together, it should be minutely and carefully examined before it passes into the hands of the smith. The ends of the spokes should not press too closely on to the felloes, and the felloes should not bind too closely upon each other; the latter should be just about the distance of a saw-cut apart. When the wheel is "passed," and the stock-hoops put on, it should be screwed down tightly on the wheel-plate, and the tire put on red-hot, and in order that it should be at an even heat, it should be heated in a furnace specially constructed for

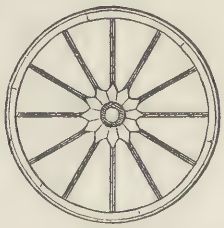


Fig. 8.

the purpose. It should be rapidly adjusted and rapidly cooled, to prevent it burning the rim of the wheel, and care should be taken that the cooling process be equally distributed all round, as by the contraction that takes place in the iron, an irregularity in this respect may be caused, which will be to the detriment of the wheel. The next thing is to rivet the tire on, and the wheel is completed. The tire should press equally at all parts of the wheel, and draw all the joints closely up, and it should be riveted on with a rivet at each side of the felloe-joint.

We have been thus minute in describing the structure of the wheel, because on this part of a vehicle so much depends, for however mechanical contrivance may distribute the wear and tear over the different parts, it all at last concentrates on the wheel; it is highly necessary, therefore, that the greatest pains should be taken in its construction. We have said that very little thought appears to have been given to this branch of industry, and we might advance argument and illustration to prove that the principle on which wheels are at present constructed is not sound, but it is no part of our purpose now to enlarge upon this or any other particular department in carriage-building. We will remark, however, that the stock is not necessarily the foundation whereon to build a wheel, and further, that there are many objections to its being so constituted. In the first place, when its centre is all scooped out for the reception of the axle-box, and its sides are mortised to receive the ends of the spokes, it is nothing but a mere shell. Every mortise-hole is more or less a receptacle for water, which the best workmanship cannot wholly exclude, and as one part of the stock is certain to be more porous than another, that is the part that will soonest absorb wet and begin to decay. If, therefore, the stock could be dispensed with, greater durability would be ensured.

A thoughtful inventor, turning these things over in his mind,

has during the last few years produced a wheel of novel construction, which is found practically to be superior to the one in common use. All the spokes, instead of being shouldered down to enter the stock, are made taper-wise, or rather wedge-shape at that end, and instead of the wheel being constructed from the centre to the felloe, it is constructed from the felloe to the centre. Every felloe is made and fitted with its two spokes, which, as they converge towards the centre, press upon each other in such a manner, that when the whole periphery is put together, a solid centre is produced by the spokes themselves, as represented in Fig. 8; so that, instead of being dependent upon a wooden stock, the spokes are dependent upon each other, and by being tightly wedged together create a mutual support and resistance; the whole are firmly secured by two metal flanges, one at the back, and one at the front of the centre of the wheel, which are tightly screwed up, by which means the greatest possible amount of solidity is obtained for the entire structure of the wheel.

This invention is due to Messrs. McNeile Brothers, of the Patent Steam Wheel and Axle Company; and it is a significant fact that wheels similarly constructed have, for a considerable time, been adopted in the Royal Artillery; moreover, they have been extensively tested on street cabs, heavy carts, and hack carriages, and, so far as we are aware, have invariably maintained their character for superiority. For ourselves, we can see that wheels so constructed must possess some peculiar advantages. There is no stock to rot, and the wheel cannot in any sense be spoke-bound, as is frequently the case in wheels of ordinary construction, by the mortise in the stock and the bore in the felloe not ranging in a true line with the spoke. In the growing desire to produce wheels of light construction, great efforts have been made of late years to reduce the size of the centre, and the inventors of these wheels have obtained this object in a pre-eminent degree. At the centre their wheels are exceedingly light and ornamental in appearance, and to render them still more uniform, they have shortened the arm of their axles, and consequently curtailed the length of the axle-box, so that there is the smallest possible projection at the centre of the wheel. At the same time, all the advantages and peculiarities of Collinge's principle are retained. In the ordinary Collinge's axle, the bearing is not upon the whole length of the arm; and practically speaking, Messrs. McNeile have in their axles cut out all that part which is useless in this respect, so that although their axle-arm is considerably shorter, the bearing is the same as in Collinge's axle of the ordinary construction.

We have now described in detail every part of one description of carriage, the manner of producing it, together with the manner of putting all these separate parts together, and we have what is familiarly known in the trade as a "brougham" complete in the wood and iron: we will next proceed to the decorative department of painting and lining, and the general finishing.

We have already explained that the roof and upper quarters of a brougham body are covered with leather. It is all important that this should adhere thoroughly and completely to the panelling over which it is strained, so as to present a solid and even surface, and it is difficult at all times to detect whether it does so or not until the painting is completed, and the gloss of the varnish renders it disagreeably apparent that it does not. This, of course, is altogether too late for such a discovery, and as there is no cure for it, we must by all means endeavour to prevent it, because if the leather be detached or become so at any point, it will then form patches or blisters, which nothing can permanently remove but stripping off the leather and recommencing the work.

Fig. 7 is the diagram alluded to in our last paper, showing an invention for throwing the back wheels further forward.

Different coach-builders differ as to the best and safest means of putting on the leather. Some advocate paste as the best adhesive material, but there is the risk of paste being either gritty or lumpy, and however slightly it may be either one or the other, the result will certainly show itself through the leather when it comes to be varnished. Glue, for this reason, is a safer adhesive material, but we consider the best material for this purpose to be smudge, which consists of the refuse from paint and varnish pots, and therefore contains a number of fatty, oily substances of a thick glutinous nature that is both waterproof and elastic. It is no matter, however, what be the means employed for the purpose of adhesion, if the leather be not properly sleeked down; every particle of air or water must be carefully expelled from beneath the leather, and in nailing it down great care must be taken not to leave hammer-marks on the surface, for such marks will show, when the painting is finished, in a series of round rings. The proper way to avoid this is never to attempt to drive the nails or pins home with the hammer, but to use a punch specially made for the purpose.

Having taken all these precautions, and left the leather for several days to get thoroughly dry, the process of painting may be commenced, and here we are beset with new difficulties. Wood, and especially leather, is of such a porous nature, that unless consolidated by some chemical process, paint and varnish will not protect it sufficiently to exclude the atmosphere totally; consequently the numerous pores are subjected to the changes of temperature, which cause them continually to expand and contract. It is highly essential, therefore, that in the surfacing process we should apply substances that retain elasticity.

There are two very important things to be studied in coach-painting. First, to form a surface hard enough to hold out the varnish and disguise the grain of the wood, and second, to have the first and intermediate coats of paint sufficiently elastic to adhere and yield to the natural action of the wood, without cracking or flaking off. In effecting one of these results we are apt to effect the other; and nothing but the utmost care on the part, both of the manufacturer of the essential ingredients, and of the person who prepares them, can ensure durability. The usual mode of proceeding is to prime over the leather-coated parts with two thin coats of black Japan, reduced with a little turpentine. The remaining portions of the body are primed with light lead colour, mixed with a little raw oil and turpentine, and a small quantity of sugar of lead to help its drying. In the next place the body receives two thin coats of colour, and the nail-holes, etc., are stopped with hard stopper, made of dry lead mixed with Japan gold size. Five coats of filling-up are next added, being mixed as follows:—

2 parts of filling-up stuff.	1 part of Japan gold size.
1 „ „ tub lead.	½ „ „ bottoms of wearing varnish.
2 „ „ turpentine.	

These five coats must be laid on in the same manner as heavy coats of varnish, one coat per day, and three additional coats of the same are generally added to the parts covered with leather. Throughout all this process, great care must be taken to keep water from the leather, to which it is very injurious, and this is one reason why it is covered with so many coats of rough stuff. The receipt here given is a standard one, and is guaranteed to rub well, and to a smooth surface.

SHIP-BUILDING.—XXIV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE OPERATIONS OF SHIP-BUILDING (*continued*).

CONTINUING the survey begun in the preceding paper, we have next to glance at the *order* in which the work of building iron ships is usually conducted; and will begin with the case of a transversely-framed vessel, with a bar keel, similar to that illustrated by the part section (Fig. 20, Vol. III., page 150).

The keel is first laid on the blocks, and the scarfs connecting the lengths are riveted up. The stem and stern-post are also generally prepared and fixed in place before the framing is begun. The preparation of the frame angle-irons, reversed frames, and floor-plates goes on simultaneously, and these parts are commonly combined and riveted together as individual frames before they are raised, the operation of riveting up being performed after the frames have been laid across the keel near their proper stations. The deck-beams are also in hand at the same time, and if not supplied in a finished form by the manufacturer they are prepared in the ship-yard, being carefully adjusted to the proper round-up, and lengths. If the vessel be of only moderate size, say from 600 to 800 tons burden, all the deck-beams are riveted to the frames before the latter are raised; and for larger ships at least one tier of beams would be so riveted, to act as cross-spalls when the frames are lifted, and to lessen the work to be done afterwards.

When this stage of the work has been reached, the finished frames, with the beams attached, lie, as we have said, across the

keel from stem to stern; and they are raised into place by means of "tackles," or "purchases," being "plumbed" and "horned" to ensure correctness of position. Various plans are followed in raising the frames, some builders beginning aft and working forward gradually, others reversing the order, and others commencing amidships and working forward and aft simultaneously. It is usual to fix a harpin near the height of the upper ends of the frames, and another at or near the height of the bilge, before the frames are raised, in order that they may be at once supported, to some extent, and afterwards to add such other harpins as may be required, in order to "fair" the frames. When this operation has been finished, and the frames have been secured to the harpins, progress can be made at once with the work of fitting and riveting the keelsons, stringers, etc., in the hold; fashioning and fixing the stringers, ties, etc., on the various decks, or completing the tiers of beams not put in place before the frames were raised, and also in preparing and riveting the outside plating.

There is obviously a remarkable contrast between the ease and simplicity of the foregoing processes in building an iron ship, and the comparative difficulty and complication of the corresponding processes in building a wood ship. Of course, in the latter case the frame-timbers may not be built up in place piecemeal on the plan described in the preceding paper; but the two bends in one frame may be put together on the ground and raised bodily, and this is done in many cases. But even under these circumstances the beams cannot be combined with the frames before they are raised, as they can be in an iron ship; and temporary cross-spalls, as well as other struts and ties, have to be fitted to prevent change of form in the frame when it is being raised. Moreover, the shelf-pieces and clamps have to be fitted in the wood ship before the beams can be put in place, and other works must be performed before much progress can be made upon the decks. It is noteworthy, too, that the fastening of the outside plating need not be deferred until the inner works are performed, but as soon as the plates are fixed they can be riveted and caulked. In this respect also time is gained upon the wood ship.

Respecting the remaining works on an ordinary iron ship little need be said. The bulkheads are usually prepared and fitted together outside the ship, and afterwards put in place and riveted up. The fitting of subordinate parts of the structure, in the hold and on the decks, is proceeded with as seems best under the circumstances of each particular case; and according to the urgency of the work and the number of men employed upon it, so would its order be regulated.

It should be fully understood that the description given above is only intended to illustrate a common method of conducting the work of iron ship-building, and one which seems, on the whole, preferable to other plans, when the transverse system of framing is used, although it is by no means universally adopted. For example, instead of putting the frames and beams together before raising them, many builders prefer to put the *frame angle-irons* in place separately, and to fair them by harpins, before combining them with the floor-plates and reversed frames, which latter pieces are subsequently put in place and riveted to each other as well as to the frame angle-irons. After this has been completed the beams are got in, and the remaining portions of the work are proceeded with much as on the other plan.

There can, we think, be no question that the work of riveting up the various parts of the frames, and of attaching the beams thereto, can be performed more readily and expeditiously before the frames are raised than afterwards, and the main argument advanced in favour of the plan of raising the frame angle-irons separately is that they can then be *faired* with ease, whereas when riveted to the reversed bars, floor-plates, and beams it is most difficult to adjust them. There is doubtless some force in this argument, seeing that in an iron ship correctness of form can only be ensured by fairness in the framing as prepared, no operation corresponding to the "dubbing out" or "reconciling" of a wood ship's frame being possible. With care, however, on the part of the draughtsmen who prepare the curves to guide the workmen in bending the frames, and care also in the conduct of the latter operation, it seems possible to secure an amount of fairness in the frames sufficient for all practical purposes when they are put together before being raised; and in view of actual and extensive proof of this fact, it seems, as we said before, preferable to use that method of construction.

In passing, it will be sufficient to say respecting the order of the work on ordinary composite ships that, so far as the framing, longitudinal strengthenings, fitting of deck-beams, and the remaining iron portions of the structure are concerned, the plans followed are identical with those described above for transversely-framed iron ships. Special methods are, however, required in fitting the wood keels, stems, and stern-posts; and before the outside planking can be worked the iron bilge and sheer strakes, as well as the diagonal ties, must be fixed and riveted upon the outside of the frames.

Longitudinally-framed iron ships have to be constructed on plans differing considerably from either of those described; and to illustrate the method of procedure we will glance at that adopted in building an ironclad on the bracket-frame system, as shown in section by Fig. 23, Vol. III., page 224.

The flat keel-plates and vertical keel are first prepared and fixed in position on the blocks, the amidship portion being put in place first. A tier of the short transverse frames (F F), with the brackets (B B) attached, is then put in place amidships, their positions having been previously indicated on the vertical keel-plate. The heels of these frames are temporarily secured to the vertical keel, and under their heads a ribband is secured, and shored, just like the lower harpins H in Fig. 63, page 189. Next the amidship plates of the lowest longitudinal frame (L in Fig. 23) are fitted to the heads of the short transverse frames, and temporarily secured. Another tier of short transverse frames is then put in place above this longitudinal, and under the heads of this tier also a ribband is fixed, after which a second longitudinal is fitted, and so on until the uppermost longitudinal, forming the armour shelf, is reached. The plan will therefore be seen to be very similar to that followed in framing a wood ship, when the timbers are raised singly; and the remarks made in a former paper as to the difficulties attaching to the construction of iron ships with longitudinal framing, as compared with those having only transverse framing, will be seen to be well founded. At the same time, the great advantages in point of structural strength resulting from the use of longitudinal frames must not be forgotten.

During the time occupied in carrying up the various tiers of frames amidships, the framing is also being extended forward and aft, and it is advantageous to follow this order, because a considerable time is usually required to prepare the massive forgings forming the stems and stern-posts of these vessels, so that the framing of the bow and stern must necessarily be left incomplete for some time. Reverting to the amidship portion, the next stage in the work of framing is fixing the continuous reversed frames (C C), and hoisting in the vertical frames behind armour. This completes the operation, with the exception of the trifling fairing generally required, and the frames behind armour are usually secured in place by means of ribbands and cross-spalls, similar to those fitted to the top timbers of a wood ship.

Nearly all the parts of the framing have consequently to be riveted up after being put in place, and until a considerable portion of this work is finished the outside plating cannot be commenced. The fixing and riveting of the inner skin depends largely upon the completion of the outside plating, and is undertaken when convenient. The skin-plating behind armour, and some other parts of the work, are not dependent upon the completion of the lower portions of the structure, and are pushed on separately. The deck-beams are also prepared and put in place as soon as possible, in order that the work on the decks—plating, planking, and framing hatchways, etc.—may be commenced. Bulkheads and other arrangements in the hold are also undertaken as soon as the inner skin is sufficiently advanced.

Throughout the construction of the ship the work amidships is farthest advanced, and it is at that point that the first wood backing behind armour and the first armour-plates are secured. The operations of bending these massive plates to their proper curvature, planing the edges and butts, drilling the bolt-holes, and fixing the plates on the ship's sides, are all worthy of separate treatment; and we regret that the space at our disposal is so limited as to prevent us from describing them, or indeed from giving more than the barest outline of any of the operations of ship-building.

COTTON-SPINNING.—I.

By J. Robertson.

THE FACTORY—ARRANGEMENT OF THE ENGINES—SCUTCHING OR BLOWING-ROOM—MIXING—GINNING—SCUTCHING MACHINES.

The art of cotton-spinning embraces not merely the single process by which the raw material, previously prepared, is finally converted into thread, but essentially all the preparatory operations.

The cotton factory, as it is now almost invariably constructed, and apart from the architectural ornamentation which not unfrequently is found tastefully combined with it, is a huge block of four or five storeys in height, and from eighty to one hundred feet in width. This excessive width is easily accounted for. The experience which has been obtained in this branch of industry has led spinners to adopt, as a rule, mules containing 700 to 900 spindles. Many years elapsed after their introduction before this number was thought practicable; gradually, however, as improvements developed the powers of the machine, it was found possible to exceed this very considerably. Mules of 1,100 and 1,200 spindles have been worked. But yet the number already specified as being fixed upon by practical men, is found in every way to give the greatest satisfaction. The cost of maintaining the machines and the cost of attendance is, in this case, at a minimum. Now as the rove creels which stretch along the back of the mules, and stand about six or seven feet high, would seriously interfere with the light were

The aim of the cotton-spinner is to strike the quality of yarn suitable for the market, and to maintain uniformity in this. In consequence of the difficulty of obtaining uniformity in the quality of cotton of even the same class, and the multiplicity of the operations through which it has to pass, in any one of which defective machinery or negligence on the part of the attendants, has a very prejudicial effect, this is no easy matter; indeed, anything more than an approximation to uniformity is impossible. To obviate as far as practicable the difficulties arising from this accidental difference of quality, is the object of the first manipulation to which the cotton is subjected. This is *mixing*. The method usually adopted is to spread out the contents of a considerable number of bales in thin layers, one above the other, until a great pile is formed, from the side of which the raw material is taken to the first machine.

It is not to be supposed that a "mixing" of cotton is always necessarily of the same *class*. Generally speaking, the lower numbers are made entirely from East Indian, or other low class cotton, medium counts from American, and the higher from Egyptian or good American. Intermediate numbers, however, are very frequently made from a "mixing," which embraces several kinds of cotton in varying proportions, according to the judgment of the spinner.

This first manipulation then having been accomplished with a considerable amount of care, the raw material is sufficiently analysed in staple, strength, and colour, to be passed on through the various stages by which, ultimately, it becomes converted into finished yarn.

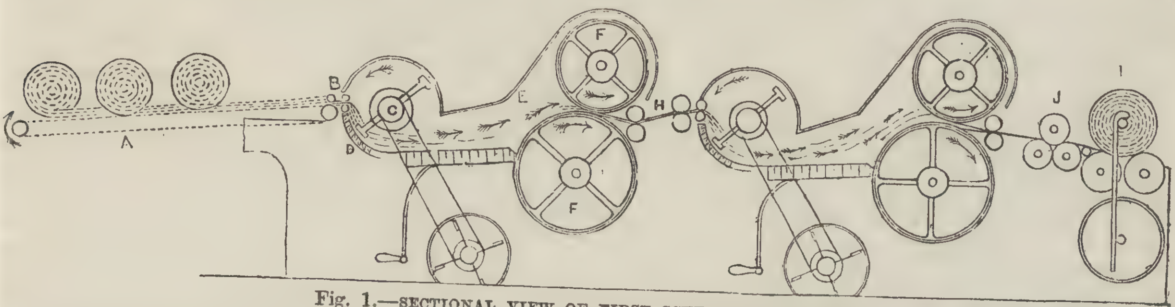


Fig. 1.—SECTIONAL VIEW OF FIRST SCUTCHING MACHINE.

they placed longitudinally, they must be placed across the building. The full benefit of the side windows is thus obtained, and an uninterrupted flow of light is permitted along the whole of the mule. As a necessary consequence of this extreme width, and the need of abundance of light, a great improvement upon the old style of building has been made, as regards the height of the ceiling. Formerly a height of nine feet or thereabouts was considered amply sufficient for this purpose, whereas now it is commonly fourteen or fifteen feet, a difference which must exercise a favourable influence on the health of the operatives.

The first storey is generally set apart for the preparation-room, which is in some cases supplemented either in the second storey or by a side shed. Here the carding-engines, lap-machines or doublers, drawing-frames, and roving or fly frames are systematically arranged, so as to economise labour, and prevent confusion when the cotton in process is intended for yarns of different "counts" or "numbers." At this point, it may be explained that yarns are designated according to the count, or number of hanks of 840 yards, in each pound weight. Thus, yarn having thirty hanks per lb. is called No. 30, forty hanks per lb. No. 40, and so on.

The "scutching" or "blowing" room is most frequently a detached fire-proof building, on account of the danger which arises from stones, metal, and even more inflammable substances, carelessly packed along with the cotton, coming into contact with the rapidly revolving heaters, and thus igniting the fibres. The size and arrangements of the blowing-room are dependent upon the quantity of cotton to be passed through it, and various other considerations. All the departments in which the different operations of preparing or spinning are carried on, are heated by means of steam-pipes to an uniform temperature of about 75 degrees.

Before leaving the hands of the planter, the cotton is subjected to a rough cleaning process called "ginning," by which the seed is stripped from it. This, however, leaves a large quantity of broken seeds, leaves, sand, and other impurities. In this state it is packed in bales, and pressed into the smallest possible bulk, for convenience in carriage, by means of steam or water power. On opening out the bales, it is found that the cotton has become caked and clotted in consequence of the excessive pressure to which it has been subjected. To loosen the fibres, and to render them soft and flocculent, as well as to separate them from extraneous matter, is the object of the first process. This is usually accomplished by means of the "opener."

This is a very simple machine, very much of the nature of a threshing-mill. It is of various construction, different machinists carrying out their own ideas as to the most suitable arrangement for effectually loosening and opening the fibres without injuring the staple, or making unnecessary waste. The main features of all, however, are similar. The cotton is passed into a circular enclosure, partly formed by a grid of angular iron bars, inside of which revolves an iron cylinder covered with teeth. These teeth strike the fibres with great violence, throwing the foreign weightier matter out between the bars of the grid, and loosening the fibres themselves, which then float forward against a perforated zinc or wire cylinder, from the interior of which the air is exhausted by means of a fan. The dust and sand which have been set free by the beater, pass through the cylinder with the blast, and are lodged in a chamber beneath, or are thrown into the atmosphere. The cotton is discharged by the revolving cylinder or dust-cage in a soft and downy heap.

In some machines there are several toothed cylinders, which successively operate upon the fibres as they pass through.

Though usually the toothed cylinder lies in an horizontal position, there is a very excellent "opener" in which it is vertical, and of a conical form, with the small end of the cone at the bottom. Being surrounded with a conical grid, the cotton which enters at the bottom ascends spirally and passes to the dust-cage from the top. It is obvious that there must be a greater likelihood, by this arrangement, of the weightier ingredients which are mixed with the cotton gravitating through the grid, and not being carried along with the cotton fibre itself.

The "opened" cotton is next taken to the first *scutching-machine*, with the object of being still further separated from sand, seed, leaf, etc. Here it is spread in a uniform layer upon a travelling lattice or feed-table, a certain fixed weight of the cotton being spread upon a certain space. Great care must be observed in this operation, otherwise it will be impossible to produce yarn of uniform weight or size. A new method of obtaining accuracy in this department has been largely introduced of late years. By means of levers worked by the upper feed-roller, and operating upon a belt connecting two conical drums, a varying motion is given to the lattice. Then, when the feed-roller rises in consequence of the cotton being spread too thickly upon the feed-table, its motion is at once retarded; and on the other hand, when the roller sinks on account of there being little cotton passing under it, the speed is accelerated, so that more is immediately brought forward to supply the deficiency. This is found to work with wonderful accuracy. The cotton having been placed upon the feed-table, is carried forward by it until it is taken hold of by a pair of toothed or fluted rollers, and passed on to a second pair. Issuing from these it is struck with great force by the *beater*. This is composed of two, and sometimes three iron bars or blades, going at the rate of about 1,500 revolutions per minute. Above, it is enclosed with a semi-circular casing of sheet iron, whilst under the point at which the cotton enters, and concentric with the circle described by the blades, there is a grid of narrow iron bars. These have their upper edge slightly projected, so that seed and leaf struck from the fibres are caught and directed through the interstices into the receptacle beneath. From the beater there is an enclosed passage to a pair of perforated zinc cylinders similar to that in the opener, and as the air exhausted from the interior of these by the fan can only be replaced through the grid, the light fibres cannot follow the weightier ingredients, but float loosely forward with the draught until they impinge against the cylinders. Whilst the dust freed from the cotton is sucked through the perforations and thence thrown into the atmosphere, the cotton itself is rolled out between the cylinders, and by a second series of toothed rollers carried forward to a second beater and pair of dust-cylinders. It is now finally delivered in the form of a felted web, to which cohesiveness is given by compressing it with one or more calendar rollers before being wound up in the form of a large bobbin or *lap*. By referring to Fig. 1, in which the outlines of this machine are shown in section, the reader will be better able to understand this process. A is the travelling endless lattice upon which the cotton is spread, B the feed-roller, C the beater, which is also shown longitudinally in Fig. 2; D the grid of angular bars, E the enclosed passage through which the fibres float, having a grating with a false bottom, into which the refuse falling is retained until removed at regular intervals;

Fig. 2.

F are the dust-cages, H the rollers which carry forward the cotton to the second beater and dust-cylinders, J the calendar roller, and I the finished *lap*.

As the cotton in this state is still far from being thoroughly purified, the laps are taken to the second scutching-machine, similar in almost every respect to the one already described. To equalise the weight and quality of the raw material, three laps are placed upon the feed-table, and are unwound simultaneously. To render the lap produced by this machine equal in thickness to one of those which feed it, it requires the dust-cages to deliver at three times the rate at which the feed-rollers take in the cotton. Usually the second scutcher has but one beater and one set of dust-cylinders.

Though the raw material is now comparatively free from seed, husk, leaf, etc., there are still remains of these impurities, which it is absolutely necessary to separate from it. The fibres also which are irregularly jumbled together in the lap must be laid parallel, and those which are too short in staple thrown out. All these objects are obtained in the next process—*carding*. This is by far the most important of all the preparatory operations, the quality of the yarn being dependent, in a great measure, upon the care and skill with which it is conducted.

SEATS OF INDUSTRY.—XXXV.

SAN FRANCISCO.

BY WILLIAM WATT WEBSTER.

San Francisco, the principal town in the State of California, although not the capital, is the largest and most important commercial city on the western shores of North America, and well entitled to be called the Queen City of the Pacific. It is one of the most modern of the great trading centres of the world, and it is a notable instance of a town that owes its creation and rapid growth to the discovery of gold in its immediate vicinity; but its natural advantages for the prosecution of commerce, and the fertility of the adjacent country, would suffice to maintain its prosperity, although the gold deposits of California should become exhausted. There is evidently a great future before San Francisco, and its past history possesses a peculiar interest.

A mission of St. Francis of Assisi, frequently called Dolores, was established near the site of the present city in 1776, by two Spanish monks named Francisco Palou and Benito Cambon. This mission devoted itself to agricultural pursuits, and amassed great wealth in flocks and herds. In 1825 it had under its care 1,800 Indians, and possessed 76,000 cattle, 79,000 sheep, and 3,034 horses, besides a vast amount of other kinds of property. For upwards of half a century the mission flourished in unabated prosperity, but in 1834 the country was placed under the control of the civil powers, and the property of the mission was secularised. After this event it rapidly declined. There were a few huts built of adobe (sun-dried bricks) scattered along the borders of the bay in 1830, and small trading vessels were at that early date in the habit of visiting the port once or twice a year, for the purpose of bartering manufactured goods for hides and furs, with the Spanish settlers, the Indians, and the Vaqueros, or half Indians, who inhabited the district. Among the first undertakings of the civil authorities, who wished to encourage colonisation, was the construction of a village called Yerba Buena, near the site of the present town-hall of San Francisco. The first house was erected in 1835, by an agent of the Hudson's Bay Company, and the first survey of streets and town lots took place in 1839. It is known that gold had been found in California about this date, and it is surmised that the Mission Fathers were aware of its presence. In 1842, Don Abel Stearns sent some ounces of gold to Washington, that he had obtained from an Indian; but it was not till four years later that the precious metal was discovered in any quantity. An American man-of-war entered the bay in 1846, and took possession of the place in the name of the United States; and at the conclusion of the war then in progress between the United States and Mexico, California passed into the hands of the republic. Up to 1847 the town was known as Yerba Buena, but in that year the *ayuntamento*, or town council, changed it to San Francisco. The population at this time numbered only 450. When rich gold deposits were found at Fort Suttee in 1848, and the actual gold fever set in, the town was for a brief period nearly deserted, but at the approach of the wet season it was crowded as it had never been before. So instantaneous was the effect of this discovery on the fortunes of the place that, in the following year, San Francisco sprung into a great commercial centre, and in 1850 it became a corporate city. In consequence of the rush of adventurers from all parts of the world, the price of everything rose to an almost fabulous height, and the assessed value of real and personal estate in the city for 1850 amounted to 21,621,214 dols. In consequence of the inability of the municipal authorities to protect life and property, a vigilance committee was organised by the inhabitants in 1851, and several criminals were executed; and again in 1856, Lynch law was reduced to a system in San Francisco.

As a town, therefore, San Francisco is little more than twenty years old. By 1860 its population numbered 56,802; in the census of 1870 the population is returned at 149,473; but according to Mr. J. G. Player-Frowd, who has just published a work on California, it was found after careful research to amount to 172,750 souls, of whom 8,000 were travellers, that number, on an average, arriving in and leaving the town daily. The analysis of the census for 1870 shows the mixed character of the population, nearly one-half of the inhabitants being of foreign extraction. It was found that the city at that date contained 25,000 natives of Ireland; 13,000 Germans; 11,000 Chinese; 7,106 Britons; 3,548 Frenchmen; besides Italians, Mexicans, Swedes, Norwegians, and Swiss; and about 2,000 coloured persons. The disproportion between the sexes is a noteworthy feature of the population of San Francisco and of the whole State of California. At one period it was estimated that there were in the city from three to five men for every woman. As might be expected, from its dependence on the gold mines, gambling is the besetting sin of San Francisco, and it is believed that in the rainy season, when large numbers of miners are in the city, gambling is carried on to a greater extent here than in any place in the world. From Consul Booker's report upon the trade of the State for 1871, we learn that there are 425 factories and mechanical works established at San Francisco, which give employment to about 9,000 men and 450 women. Among these we may note 78 cigar manufactories, 34 iron foundries, 35 carriage and wheel factories, 23 breweries, 21 marble and stone works, 17 tanneries, 13 shoe and slipper manufactories, 11 grist mills, 15 soap factories, 10 saw mills, and sash and door manufactories, 5 billiard-table manufactories, 10 hat and cap manufactories, 1 silk manufactory, 2 pianoforte manufactories, 2 woollen mills, etc. The wages of artisans are very high, but the cost of living is also very great. To quote again from Consul Booker's report, bricklayers earn 20s. per day; ship-carpenters, grist-millers, masons, maltsters, millwrights, and riggers from 16s. to 20s. per day; stonemasons from 18s. to 20s. per day; house carpenters, painters, plasterers, and plumbers, 16s. per day; and common labourers from 7s. to 8s. per day without board, and from £5 to £6 per month with board. The bricklayers, stonemasons, and plasterers work only eight hours per day; the other artisans work ten. Although the wages of domestic servants have slightly declined, owing to the incursion of Chinamen, who are exceedingly handy at many kinds of domestic work, family cooks still receive from £48 to £74 per year; housemaids from £48 to £72; nurse-girls from £36 to £48; and men-servants from £84 to £110. The high price of labour is a great check to the progress of manufactures in San Francisco, and the introduction of Chinese labour still meets with formidable opposition. On the 31st of December, 1871, the savings' banks and loan societies of the city had on deposit £7,406,675, on account of 41,590 depositors, against £6,257,910, on account of 36,862 depositors, on the previous 31st of December, showing an average for each depositor in 1871 of £178 against £169 in 1870. This is a striking evidence of the prosperity of the working classes of San Francisco.

The bay of San Francisco forms one of the most spacious and safest harbours in the world, being fifty miles long, and averaging eight miles in width, exclusive of the bays of San Pablo and Suisoon. It has a coast-line of 275 miles, and the entrance, called the Golden Gate, which is little more than a mile in breadth, is deep and easy of navigation. In order to overcome the shallowness of the water close to the city, a wharf, 2,300 feet in length, has been projected into the bay, at which vessels of all sizes can moor in safety. The value of the gold exported from San Francisco in 1867 was returned at £8,330,250; but it has been estimated that the total exports of the precious metals for that year, including large sums carried by miners and others to the United States, Mexico, and elsewhere, amounted to £9,585,538. The other exports for 1867 reached a total value of £4,493,150, of which amount £1,663,730 went to Great Britain. The imports from Great Britain for the same year reached a total of £3,704,941, about one and a half millions sterling consisting of cotton, linen, and woollen goods. Among the principal articles of Californian produce exported from San Francisco in 1867 were included wheat, to the value of £1,890,540; flour, £643,473; wool, £243,100; hides, £65,800; quicksilver, £186,250; ores, £106,300; and wines, £27,400. The first shipment of wheat and flour from the port was made in 1856, and went to New York. In 1867, 35,683 passengers arrived by sea at San Francisco, and 20,419 left by sea. There were over 100 steamers employed in navigating the inland waters of California in that year, 87 of which, measuring 20,460 tons, were registered at San Francisco, and the custom receipts of the port amounted to 7,442,881 gold dollars. Regular steam communication was established with Hong Kong in that year, the voyage taking six days. One of the most notable features of the commerce of San Francisco is the rapid extension of the trade between that port and Japan, since the throwing open of the latter country to the commerce of the world, nineteen years ago; and this is a trade that is likely to increase enormously as the resources of Japan are developed, and its institutions reformed, under the new and enlightened policy of its present rulers. During the past three years a considerable decrease has taken place in the exports of gold and silver from San Francisco, the total value in 1871 being £5,908,128; and during the last two years, owing to drought, the exports of native produce have also declined. The total value of the Californian produce shipped at San Francisco only amounted in 1870 to £3,569,630, and in 1871 to £2,790,234; but in addition to the exports by sea, about £3,000,000 worth of goods were dispatched eastward from the city by rail. But notwithstanding the drought, the general trade of San Francisco during the year 1871 was very prosperous.

San Francisco is situated on a sandy peninsula which separates the great bay from the Pacific Ocean, and lies six miles southward from the Golden Gate. It is far from beautiful as seen from a distance, and the vicinity is described as desolate in the extreme. "A few scrub oaks," says Mr. Player-Frowd, "whose dwarfed and knotted branches all point away from the prevailing west wind, are to be met with at rare intervals. The *Ceonothus*, a species of privet, is the only indigenous shrub that has any pretensions to beauty. For eight months of the year a strong breeze, laden with fog, blows from the Pacific, and clouds of fine sand accompany it in its progress over the peninsula." A few years ago, during the wet season, the streets of San Francisco were puddles into which carriages sunk up to the axles, and during the dry season the dust was intolerable. But the streets have now been floored with stout planks, and a great improvement has been effected in them in both of these respects. The city is, on the whole, regularly laid out, and the houses well built, and many of them handsome; but the streets in the older quarters are narrow, and the houses mean-looking. A portion of the site is hilly, and at one corner stands Telegraph Hill, the highest eminence, which has nearly been "whittled" away in the attempt to run streets in straight lines over and across it. Several of the streets are very fine. The principal business street is Montgomery Street, a large portion of which, however, has been found too narrow for the increasing traffic, although a part of it still retains its old dignity, being occupied with the great hotels, and some of the finest shops in the city. But the best street in San Francisco is Market Street, a thoroughfare ninety feet in width, and extending for five miles in a straight line, and with a street railway running nearly its whole length. There are a large number of churches of all denominations, and several theatres in the city, including a Chinese temple and a Chinese theatre. San Francisco is moderately well supplied with schools, the expenditure for the maintenance of public schools in the city and country for the year ending June last having been about £100,000. No less than twelve daily, twelve weekly newspapers, and four magazines are printed in the city, and more than one of the newspapers are very ably conducted, and have a reputation even in Europe. Some of these papers are in German, French, and Spanish. The city is well provided with hospitals and other charitable institutions, and improvements are constantly being carried out. Consul Booker, in his report for 1871, says:—"Some very handsome residences have been built. A park, not of the most desirable character, but with the advantage of being within two miles of what may be called the centre of the city, is being laid out." San Francisco has suffered severely and frequently from fires, but the damage has always been speedily repaired, and since houses of brick and stone have been substituted for wooden houses and tents, the fires have been less frequent and less

disastrous. The water-supply of the city is barely adequate, and a project has been started for bringing the water of Lake Tahoe from a distance of 260 miles, distributing a portion to the various mining camps and towns that intervene.

MINING AND QUARRYING.—XXXII.

BY GEORGE GLADSTONE, F.C.S.

ANTIMONY.

GEOGRAPHICAL DISTRIBUTION—SULPHIDE OF ANTIMONY—ASSAYING—REDUCTION—REFINING—PROPERTIES—USES—TYPE METAL—BRITANNIA METAL—IN MEDICINE.

ANTIMONY is pretty widely diffused in Nature, especially in combination with other ores, but it does not occur in such sufficient quantity in the British Isles as to be of much importance to the miner. It is generally to be found in tin and lead ores, but it is rather regarded as an impurity than a source of profit; though several mines were worked for this metal in Devonshire and Cornwall during the past century, when the present more abundant foreign sources of supply were unknown.

The principal European deposits are found in several parts of the Austrian Empire, but Germany and France also yield sufficient to supply the reduction works of those countries. Almost the whole of that which is consumed in England comes from the mines of Sarawak, in Borneo, which were opened up by the late Rajah, Sir James Brooke. It is brought over to England in the rough, and is here reduced to the metallic state. More recently some very good samples of the same description of ore have been obtained in New Zealand.

The Borneo ore consists entirely of the sulphide, which is the commonest form in which this metal occurs. The oxide is, however, found either alone or in combination with it, in some of the European deposits. The sulphide is a very dark-grey crystalline substance, and when free from earthy matter or other metals, generally contains about 74 per cent. of pure antimony.

The simplest plan of assaying this ore is to heat a given quantity in a crucible, after having been finely pulverised, with 4 per cent. of the cyanide of potassium. Only a very moderate temperature is required for this purpose, and as the operation is quickly performed, the risk of loss by volatilisation is reduced to a minimum. The metallic antimony, which will be found in the crucible, has then only to be weighed. A more common plan, however, is to roast the ore first, with free access of air, so as to drive off the sulphur and obtain an oxide instead, and then to fuse the oxide in a crucible, with the addition of a flux. But there is considerable risk of loss in the calcining of the ore, as it is very fusible and volatile, so that great care has to be taken in keeping the temperature moderate, and the ore well stirred, until the whole of the sulphurous acid has been evolved.

Another mode, which has some advantages, though not very accurate in its results, dispenses with the preliminary calcination by fusing the sulphide itself, with the assistance of bright iron filings. The result of this will be a mass of metallic antimony at the bottom of the crucible, overlaid by another of sulphide of iron. They can be readily distinguished, as the former is white and highly crystalline, while the sulphide of iron will rather resemble bronze. The antimony has then to be carefully separated and weighed.

A much greater heat is required in this process, so that a little of the antimony is liable to be sublimed, and some small quantity will also have entered into combination with the iron itself. In order to decompose the whole of the sulphide of antimony, and at the same time to avoid the latter source of error, it would be necessary to know exactly how much of the iron to add; but that presupposes the very knowledge which it is the business of the assayer to ascertain; so that in proportioning the quantity of iron to the charge, he can only act to the best of his judgment; and according as he has added too little or too much, he will either have some sulphide of antimony or antimoniate of iron remaining. The addition of some carbonate of soda will increase the fusibility of the mass, producing a double sulphide of iron and sodium, from which the metallic antimony can be more readily separated.

The ordinary operations for the production of the metal on a large scale bear a very close resemblance to those adopted by the assayer.

There is a preliminary one to which the rough ore is subjected for the purpose of separating it from all the earthy matters mixed with it, which will have to be described. The old plan, but which is still in use in some countries, was to heat the ore in crucibles having an opening below, and a pipe connecting them with another set of crucibles ranged on a lower level. After charging them with the crude ore, the lids were luted down and the fire got up, which played freely round the pots before passing into the flue. The pure sulphide of antimony was thus melted out, and ran down the pipe into the lower crucible.

A more modern plan is to melt the ore on the hearth of a reverberatory furnace, something similar to those used in the reduction of tin, which has a considerable fall towards the centre, from which a pipe conducts the molten sulphide into a receptacle outside. About one ton of ore can be passed through such a furnace in the course of a day, which, if tolerably rich in metal, will usually yield about half that weight of the pure sulphide.

An improvement upon this was introduced at one of the Continental establishments, which will be best understood by reference to the accompanying diagrams, Fig. 1 being the horizontal section, and Fig. 2 the elevation. It consists of a vaulted furnace, A, A, A, having three fire-grates, B, B, B, between which are two chambers, C, C, closed at the ends by iron doors, D, D, with small flues, E, E, etc., leading directly from the fire-places to the chambers; several flues, one of which is seen at F, lead from the upper part of the vault into the chimney G, which is subdivided for some distance by H, so that if necessary for repairs one side only may be used, and the workmen at the other will not be distressed by the fumes. I, I are doors for getting at the several parts of the apparatus, but which are kept closed while the furnace is in use. K, K are cylinders with an aperture in the lower part for containing the ore which has to be eliquated, and L, L are the pots for receiving the pure sulphide. These latter run upon iron trucks, and are drawn out at the doors D, D, etc., when they require emptying. The cylinders stand upon tiles made of fire-clay, and are covered with lids made of the same material. Each cylinder will hold a charge of about 500 lbs. of ore, and as soon as the operation is complete the residue is raked out, and a fresh charge introduced. This occurs about every three hours.

The sulphide of antimony having been freed by one or the other of these processes from all its earthy ingredients, is put into a reverberatory furnace for calcination, which is so arranged as to supply a large quantity of atmospheric air. The temperature must be kept moderate, and the furnace-man has to stir the charge constantly, so as to expose all of it equally to the oxidising influences. As soon as the whole of the sulphur has been evolved, and the antimony converted into an oxide, the material is ready for reduction, which is done in crucibles heated in an air-furnace. The oxide of antimony is mixed with about 10 per cent. of tartrate of potash, which takes up the oxygen and leaves the metal free.

A ready plan of reducing the metal direct from the sulphide has been adopted in Germany, but the antimony produced is not of a very satisfactory quality. The sulphide mixed with a due proportion of iron-scale or filings, to take up the sulphur, and some carbonate of potash, soda, or lime, is thrown into a reverberatory furnace, and heated for eight or ten hours. The antimony will by that time have collected at the bottom of the hearth, from which it is drawn off through a pipe into a receiver. The metal thus made has to be re-melted two or three times in a crucible along with some charcoal and alkali, before it is sufficiently purified for general purposes.

The ordinary antimony of commerce is always more or less mixed with other metals, and not unfrequently contains some sulphur which has not been thoroughly expelled. The simplest plan for purifying it is to pound it up in a mortar with 10 per cent. of nitrate of potash, and then fuse the mixture, from which the pure metal will separate itself.

It is a brittle silvery-white metal, melting at 800° Fahrenheit, of no value in the arts, except in combination either as alloys or as salts.

In the metallic state it is of special importance to the type-founder, as it serves to impart to type-metal the peculiar properties required in that manufacture. A very common compound for this purpose is from 70 to 75 per cent. of lead, 20 to

25 per cent. of antimony, and 5 of tin. But sometimes a hard metal is made without any lead at all, in which case about 25 per cent. will be antimony and the rest tin. Some makers add a little arsenic, and occasionally copper; but the metal now under consideration is an invariable constituent.

Antimony, to the extent of 10 per cent. and sometimes more, is used in the composition of the best Britannia metals. Bell-founders employ it because it improves and increases the sonorousness of other metals. It is of advantage in making castings, because its presence renders other metals more easily fusible; and in making metallic mirrors it is also beneficial, improving the texture, and thus rendering the alloy susceptible of a higher polish. Other alloys which contain antimony are more particularly described in Article XVII. (Vol. III., page 148).

It forms salts with sulphur, oxygen, and chlorine, all of which are of use, especially in medicine.

The sulphide and oxide employed for such an important purpose as this are not the impure articles found in Nature, nor even the direct products of the furnace; they are specially prepared to render them perfectly free from all noxious ingredients, and especially from arsenic, which is by no means the least uncommon.

The sesqui-sulphide may be prepared by fusing 13 parts of pure antimony with 5 of sublimed sulphur in a crucible. Another plan consists in digesting the crude sulphide itself with an equal quantity of carbonate of potash, and half as much again of slaked lime in water, in a closed vessel. The solution will then contain a double sulphide of antimony and the alkali, from which the pure salt is precipitated on adding sulphuric acid, which decomposes the alkaline sulphide.

The double sulphide of antimony and potash has long been in use, under the name of kermes mineral, for medicinal purposes; but latterly it has gone, to a great extent, out of use, as it has no special quality to recommend it in preference to another more familiarly known antimonial compound, tartar emetic—the bitartrate of antimony and potash.

By adding some dilute acid to a solution of the foregoing, it is converted into the golden sulphide, so named from its brilliant yellow colour. It contains a small quantity of oxide. It is used in medicine, and is more powerful in its effects than the preceding.

Another preparation, which is also much used for similar purposes, is a compound of this metal with chlorine. The sulphide is dissolved in hydrochloric acid, with or without the addition of nitric acid. The hydrogen combines with the sulphur and is evolved, leaving the chlorine to the antimony. The solution is thus evaporated down till it begins to crystallise in the cold; it is then distilled over from a retort, the pure terchloride being of a buttery consistence, which melts into an oily liquid at 162° Fahrenheit. From having this property it is commonly called "butter of antimony."

From this again may be prepared the oxide, sometimes called "flowers of antimony," by decomposing it with carbonate of soda, when the mixture separates into oxide of antimony and chloride of sodium, with evolution of the carbonic acid. It can also be made by burning the metal itself, when small crystals of the oxide will be found to collect at the top of the receiver.

Fig. 1.

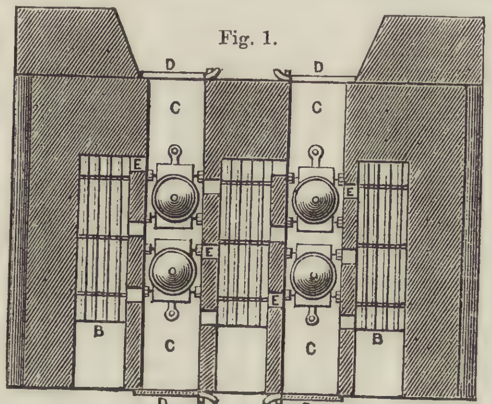
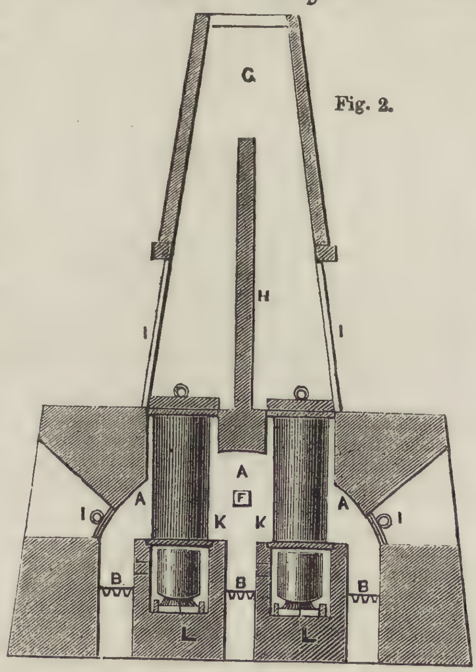


Fig. 2.



BISMUTH.

SUPPLY—REDUCTION—PURIFICATION—PROPERTIES—ALLOYS—PEARL WHITE.

This metal is often met with in small quantities in mining for other ores, but does not occur in sufficient abundance in any mineral district to render it worth pursuing for its own sake. It not unfrequently occurs in the native state, and it is from such that the principal supplies are derived.

As it melts at a remarkably low temperature, 500° Fahrenheit, it is easily separated from the earthy matters or ores of other metals with which it may be associated. All that is necessary is, first, to break up the pieces, so as to remove as much as convenient of the refuse matter, and then place the ore in tubular retorts having a slight inclination towards the orifice. In about ten minutes after the fire has been got up to the right temperature the metal will begin to flow, and in another twenty minutes, during which the ore should be well stirred up, the whole of the metal will have been melted out. As it runs into the receiver it is ladled out and cast into bars.

The metal thus produced will contain a certain amount of impurities, consisting commonly of sulphur or arsenic, and other substances; but these can be in a great measure removed by fusing the bismuth with the addition of some nitrate of potash.

It is a crystalline body of low specific gravity, and very deficient in tenacity, and it has no characteristic to render it of practical utility as a simple metal. It, however, enters with advantage into certain alloys, and some of its salts are useful in medicine.

In speaking of the different kinds of pewters and solders under the heading of "Tin," Article XVII., the employment of bismuth as one of the constituents of these has already been spoken of. They need not, therefore, be recapitulated now. In addition to those uses already named, it should be added, however, that a little bismuth greatly improves the tone of bell-metal.

The most important of its salts is the basic nitrate, commonly known as pearl white. It is formed by the addition of about 24 parts of hot water to 1 of the ternitrate of bismuth, and then evaporating to dryness, the ternitrate being first made by dissolving the metal in nitric acid and crystallising out the salt. If the preparation is to be used in medicine, it is essential to separate from it every trace of arsenic, an article most usually found in combination with it. For this purpose only about one-sixth of the water is added to the ternitrate in the first instance, in which the arseniate of bismuth will not be soluble, so that it can be separated from the rest by filtration.

The alloys which contain bismuth possess a greater specific gravity than the mean of their constituents: thus equal parts of lead and bismuth give, by experiment, 10·538 at a temperature of 14° Centigrade (equal to 57·23 Fahr.), against 10·290, which is the calculated mean.

The metal itself expands on solidifying—contrary to the custom of such bodies—and this has led to its being compared to water, though the analogy is not exact. The expansion

of the bismuth is probably due to the change in the arrangement of its particles by crystallisation, and not to loss of temperature, as up to the very point of solidification the coldest metal is found to be the densest, and to accumulate at the bottom of the liquid—not on the surface.

SANITARY ENGINEERING.—XXVIII.

SUMMARY.

In this our concluding paper upon the subject, we take up no new topics and have no fresh details to record: it is devoted to a simple recapitulation of what has gone before, and is intended to take the position of a summary, or, if we may so term it, *catalogue raisonné* of the entire series. Four leading subjects are embodied in our course: (1) Gas, as representing light; (2) the mechanical processes of artificial warming, as representing heat; (3) the best means of obtaining a supply of fresh air, under the head of "Ventilation;" and (4) Drainage and Water-supply, as connected therewith—the last, not least division of the subject, as representing what the general public consider as sanitary engineering, strictly so regarded. The order in which we have treated these various matters was decided, to a certain extent, by their relative importance. Our object in this publication is supposed to be purely technical, that is, to explain the way in which practical matters are carried out. Theory takes no place in the arena—practice and pure practice, what has been done and is being done, and how, that is the subject-matter of our communications. We may confess that the idea of commencing the series by some papers upon "Gas" was suggested by a passage in the first and best book in the world—"Let there be light." Without light, no work can be done; our days in this dull climate are short in the winter months; and therefore the best scientific appliances for obtaining light at the most moderate cost first occupied our attention.

Having light sufficient for our work, we bethought ourselves of the next requisite throughout all the winter months of the year in large factories, warehouses, printing-offices, and elsewhere—*warmth;* and therefore the second portion of our Sanitary Engineering was devoted to the mechanical details of artificial methods of warming; but with light and heat provided, there then occurred the third point, accessory, as we may say, to the foregoing, and that was the means of supplying fresh air. Gas products are unwholesome, and dry burnt air is noxious; these vapours have to be got rid of, and we therefore took up as our third heading, "Ventilation." Having given from good authorities the best data at our command on these matters, we then turned to the final and most important subject of the whole—viz., Drainage and Water-supply, not less important, but occupying for other reasons a subordinate position in the present series.

Thus generalising the main objects of the course before us, we now proceed to give a short abstract of the various papers, which, with this last contribution, have reached the number of twenty-eight. In our first paper we took up the mode of the manufacture of gas by public companies, giving the particulars of material and method, and as much detail of construction, etc., as the space at our command would admit. The subject of No. II. was gas-burners, the tools, as it were, or media through which this supply is consumed in its daily use: the difference of simple jets, bats'-wings, fish-tails and argands, the technical names for the ordinary kinds of burners, are there explained.

In paper No. III. we dealt with the method of measuring the amount of actual light obtained from these burners, and the way in which the light given by one burner might be compared with that given by another, varying sizes and capacities fairly calculated, and, as well as we could, explained the principles upon which "photometry," or the measurement of light, was carried out. The text of the paper might be "The Quality of Gas."

In No. IV. we described private gas-works, and showed how anybody, if his requirements were sufficiently extensive, could make his own gas, and save money thereby. For the detail of the appliances we must, of course, refer our readers to the paper in question.

No. V. deals with a question not of economy but of "power." A mass of central concentrated light at a high level for public rooms and buildings, lecture-rooms, manufactories, etc., combined, at the same time, with an efficient system of ventilation, is always most desirable, and we showed how those ends can be attained by the "sun-burner."

No. VI. again takes an economical view: it explains the methods by which gas is measured, and shows how a man can arrive at an accurate result as to the quantity of gas burnt in his house or factory; and while we explained the difference in the construction, we carefully abstained from expressing an opinion in favour of either "wet" or "dry" gas meters. This paper might be headed "The Quantity of Gas as distinguished from its Quality."

No. VII. explains the method of cooking by "gas," and the fittings required. A kettle may thus be boiled, or, to take the maximum view, a dinner for 1,000 people may be cooked more cheaply than by the ordinary method.

In No. VIII., our last paper on the gas question, we showed how gas was utilised for heating baths, lighting theatres at the foot-lights, generating steam-power, and various other commercial purposes.

Having thus summarised our first head "Gas," we now come to our second subject, "Warming." No. IX. of the series shows how, by circulation through a series of pipes, water *under* the boiling-point, 212°, may be utilised to diffuse heat throughout a large area at a moderate cost.

No. X. deals with a kindred topic, but with the water heated above the boiling-point, the "high-pressure" system as it is called, with strong wrought-iron tubes, and a pressure of anything under 600°.

No. XI., on heating by hot air and steam, briefly explains the construction of some of the hot-air stoves, in such extensive use on the Continent, and gives some data as to the utilisation of waste steam in factories, etc., for general warming purposes.

We thus dismiss the details of Warming, and come to those of Ventilation. In No. XII. we give, with illustrations, some of the most recent and handy inventions for the ventilation of rooms and dwelling-houses. No. XIII. treats of the ventilation of public buildings, a much wider theme, and subject to more varying conditions; the general principles to be observed we have, however, explained as clearly as we could. And in No. XIV. we give examples of some successful ventilating construction as applied to hospitals, when, in addition to heated air, respiration, and the products of combustion, air charged with the vitiated effluvia of disease has to be dealt with.

This completes the second and third sections of our subject, and brings us to the last heading—Drainage and Water-supply. No. XV. supplies the details for supply of water, with particulars of construction and cost, to towns and villages upon a limited scale—*i.e.*, when the supply is comparatively small—and will be useful as a reference where an isolated country mansion or manufactory is situated at a distance from ordinary facilities. No. XVI. takes a cursory view of the present position of the supply of the metropolis and large provincial towns, with some slight allusion to water as a mechanical *motive* power, and also to water-measurement, which is yet in its infancy as a system, but which, we hope, will be largely developed in its application at no distant day.

Proceeding onwards in our general view, No. XVII. explains the method of the manufacture of the pipes through which water is laid on, and gives some economical statistics, comparing lead with iron as the material of their manufacture, which, we venture to think, will be found worthy of attention. No. XVIII. goes one step further, and deals with the construction of cisterns, the appliances at command for the *economising* of water when the supply is likely to be restricted, and enters into a subject as yet little before the public, the desirability—we ought perhaps to say the necessity—of a provision for the ventilation of a system of pipes for water-supply or otherwise.

The water being therefore supposed to be laid on, and the cistern provided, we next come to the heading, unsavoury in its nature, but none the less important in fact—perhaps we may call it the key-note of Sanitary Engineering proper—that of closets and traps. In a long and fully illustrated paper, we have given the detail of the best modern inventions for these necessary conveniences, and explained the principle of their operation.

Paper No. XX. is devoted to an explanation of a system recently introduced, but well worthy of attention—Moule's earth-closet system. Here water-supply is dispensed with, and an efficient sanitary closet arrangement is provided, dry earth being the only requisite. For details, we refer to the paper.

In No. XXI., still proceeding in our practical sequence, house drainage is the subject. With the manufacture of the

pipes we do not here deal—that will be found in other series of THE TECHNICAL EDUCATOR: we explain only the rules for their ordinary laying, and the varying forms of construction at command. The ventilation of in-door pipes having been already explained, in No. XXII. we go into the question of the ventilation of house-drains, and give illustrations of some new matters in the way of air-escapes and disinfecting apparatus, which will, we doubt not, in future be extensively adopted, though not widely known at the present time; and from the house-drains the thread of our investigations naturally conducts us to the sewers. In No. XXIII. we give what we may call working drawings of the sewers in the metropolitan districts, and also deal with the question of subways, illustrating what we have to say by examples which have been carried out, and are now satisfactorily at work. The sewers being built, the question of their ventilation is an important one; and in No. XXIV. we give the best and most recent data upon the subject.

The disinfection of sewage and its application as a valuable commercial article are now receiving much attention. With the latter portion of the subject we do not here deal, but in No. XXV. we give particulars of what has been the result of extensive experiments in London upon the disinfection of sewage gases, and also some description of works now in operation for disinfecting sewage in a solid form.

The practical side of the question being thus disposed of, in paper No. XXVII. we give the actual result of the adoption of a comparatively enlightened system of hygiene in some of our large provincial towns, extracted from reliable Government authorities, showing clearly that the adoption of well-considered sanitary precautions has its immediate and marked result in a largely decreased *death-rate*, wherever these matters are properly taken up. The object and end of all sanitary engineering is to improve the health of the population, and the data given in the last paper show clearly that this is no chimerical idea, but that the saving of life—for it comes to that—is represented by large per-centages. For figures, we refer our readers to the details.

By means of these last figures we bring the matter, as it were, to book, and eliminate tangible results: the intermediate stages of improvements; the diminution of danger from cholera; the control—we can use no other word—of typhoid fever; and the improved physique, resulting from a better state of general health, especially among the lower classes, are elements which, though they cannot be exactly calculated and stated in figures, are very important objects of attention. If the technical information contained in this series of papers facilitates in any way the adoption of any of these, which may fairly be called the requirements of the day, the object of their publication in THE TECHNICAL EDUCATOR will be well and thoroughly attained.

SOLDIERING.—VI.

BY A STAFF OFFICER.

EQUIPMENT (*continued*): IMMEDIATE NECESSARIES.

IT will not be advisable to enter very fully into the subject of these, for their character in war differs entirely from time to time, according to the circumstances of each special case. The general conditions are easily explained.

The differences which the nature of the three chief services impose must be taken into account. Care must be taken that no more is given to the infantry soldier than he can carry during long marches, and that the weight is distributed over his body in whatever way may be most conducive to ease and comfort in marching.

Sir Charles Napier was said, during one of the campaigns in India, to have reduced even the officers' equipment to a piece of soap and a tooth-brush; and of course there are times, as in the Abyssinian campaign, when nothing whatever which interferes with the rapidity of advance can be allowed. All such extreme restrictions are, however, sure to be borne by an army with greater alacrity if they are not imposed unnecessarily. Moreover, the distress occasioned by an entire absence of means of comfort tends itself to produce inefficiency. The great object, therefore, to be obtained in all arrangements for the supply of the men's needs is, as far as possible, to develop a system of rapidly supplying any deficiencies in what they carry, and to restrict what they do carry, as far as possible, to those things only which could not certainly be supplied to them before they will need them. The total weight which, in ordinary service, each of our soldiers is intended, with the new equipment, to carry is, including the clothes he wears, a little less than fifty-two pounds.

Under any circumstances, a considerable number of rounds of ammunition in addition to the carbine is indispensable for the infantry soldier. In the British army we carry seventy rounds per man.

Some means of cooking food and carrying water is indispensable. Our men carry a mess-tin and a water-bottle. In addition, certain articles of clothing are almost essential to health, and altogether to comfort.

A sufficient supply of ammunition must be on each man's person. Our established allowance is seventy rounds per man. It must, however, be noted that the actual duty on which men are engaged in each particular case must decide the proportion of ammunition to other stores which it is advisable that each man should carry. Where an action is likely to be fought by any particular corps, the men of that corps must have their full allowance of ammunition. As usually it is not easy to provide adequate supplies of food during the period of an action, something to eat and drink is indispensable also. On the other hand, where troops are likely to be engaged in long marches without fighting, good boots and clothing become all important. During the Franco-Prussian war (1870), whole regiments were put out of fighting condition by the contractors having sold boots with brown paper soles.

In the case of cavalry, the man's capacity for carrying weight has no longer to be attended to, but that of the horse has. Moreover, food, means of grooming, and some clothing have to be provided for the horse as well as for the man. On the whole, however, the surplus weight which cavalry can carry is not very great. The artillery alone are tolerably independent as regards the necessity for providing for the immediate personal needs of men and horses. The weight of their carriages is so great, that it makes little difference whether a few extra pounds are added or not. As a rule, therefore, their gunners do not carry the stores hitherto referred to, but these are partly carried on the horses and partly on the guns.

TRAINING.

It has always been hitherto the habit to divide the subject of a soldier's "training" into two parts—"drill" and "discipline." I have pursued that division in the syllabus of the present course for this reason. We are at this moment, in military matters, in a state of transition. The nature of actual fighting has changed in most important respects. But the preparation for a soldier ought to be primarily for fighting. When, then, the nature of the fighting changes, the nature of his preparation for it inevitably changes at the same time. There, can therefore, be no question that we are now in presence of an absolute necessity for so modifying the training of our army as to meet new facts. Nevertheless, there is no body to which sudden and violent change is so detrimental as it is to an army. Hence it is before all things important that any changes of mere form which we introduce should be carefully thought out. One desires in all terms and expressions to keep as closely to the past as possible, while gradually infusing into them the new spirit which is required.

In order to understand, however, how far "training" can now properly be said to be a term precisely co-extensive with the two minor headings of drill and discipline, it is necessary to make clear first what has usually hitherto been understood by "drill." It by no means follows that the word may not have a new force given to it, which will enable it fully to include what is required.

It is said that the word is derived from an old French term signifying "soldier." It would thus be almost the equivalent of the term which I have taken as the title of these papers—"Soldiering." If that was its meaning at first, it has certainly been very much restricted since then. Practically, "drill" has included only the teaching of a soldier how personally to use his weapon; how to use it so as not to interfere with the men beside him; how to work with these by means of some definite formal movements; and, in addition, the instruction necessary to enable those who were to convey to him the orders by

which he was to act, to issue them as they were required. Let us consider first the means by which the army has been brought, under the orders of its commander, into situations from which it could act upon the enemy. It will be remembered that in speaking of the use of weapons we had to take account of the division of the army into the three great arms of the service—infantry, cavalry, and artillery—due to the nature of weapons, and to the extent and manner in which we employ the services of the horse. For each of these arms or branches of the service a separate drill is necessary.

To take first the infantry. Here our drill must be adapted to enable the men to bring into play, at different times, two different kinds of weapon, the fire-arm and the bayonet. It will have been noted that in describing the manner in which these weapons were severally used in the Peninsula, the bayonet was always the finally deciding arm. The fire was only a means of creating a certain moral effect preparatory to the bayonet charge, which though seldom carried home, was the active cause of the breaking up of the enemy's power, and of his final flight. Now, from the simplest considerations, it is abundantly clear that if men are standing one behind another, row behind row, to a great depth, they will not be able to fire so effectively as if they stand in a single or double row side by side. With two rows or ranks, each rank can, by a little adjustment of the weapons, fire well enough. Even with four ranks, if the front two kneel down, fire is easy for all four at the same time. But you cannot increase the number of ranks beyond that, and yet having your men close side by side, and close one behind the other, continue to let every man fire, for those in the middle will fire into those outside them. Hence, when actually engaged in firing at the enemy, in the old days, troops were, if possible, formed side by side of one another in not more than four ranks. This formation a few ranks deep we call a "formation in line." The formation with a succession of ranks one behind another we call a "column." With us the formation in line is in two ranks. The Prussians employ, till they come on to the battle-field, three ranks, as we also did at one time.

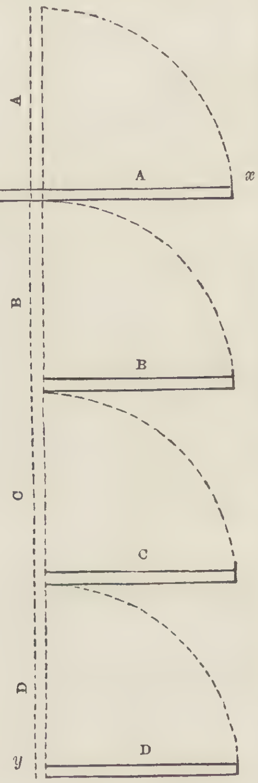
The effect of forming a succession of ranks, one behind another, is clearly that the same number of men will occupy less space in front in proportion as we increase the number of ranks which stand one behind another. A thousand men in line in two ranks occupy from A to B (Fig. 1) 1,000 feet. The same number of men in ten ranks occupy from C to D (Fig. 2) only 200 feet. The most cursory glance at the two figures shows at once how much more convenient for the purposes of rapid movement the formation C D E is. In the first place, we may be often able to find ground which will allow men to pass on a front of 200 feet, such as C D, but will not at all admit of a body in a formation so extended as A B passing at all. Secondly, it requires very much more elaborate training to teach men how to keep their places whilst they are moving forward in line, A B, than to teach them to do so whilst they are in column, C D E; for the very slightest displacement of any man in the long line A B throws out others, and as this process constantly tends to increase as the movement proceeds, the line becomes more and more irregular till, without the most extreme perfection in drill, in moving over ground presenting the slightest irregularity, all order is lost. Obviously this evil multiplies in proportion to the length of a line. Hence for an army it may practically be said that for purposes of movement the only formation is a column; for purposes of firing the only close formation is a line. By "close formation," as to infantry, is meant any arrangement of the troops in which the men stand in each rank as close together shoulder to shoulder as the free use of their weapons will allow them to stand. At present with us each man is allowed 24 inches, so that any given number of men in two ranks occupy as many feet of front as there are men in the two ranks. The rear rank stands back from the front rank one pace of 30 inches, measured from the heels of the front rank to the heels of the rear rank. In column the two ranks which form the line stand at the same distance apart as in line, whatever the nature of the column may be; but the distance of each two from the next two depends on circumstances now to be considered.

Since for purposes of movement we require columns—for purposes of firing, lines—it is clear that we must be readily able to change formation from line to column and from column to line. Now the kind of column which will most readily enable us to form line is one of this kind.

Suppose a certain number of men drawn up in two ranks in line, and divided into four parts, A, B, C, D, as in Fig. 3.

Now let B, C, D be arranged behind A in this way, where the order is such, that from the front rank of A to the front rank of B the distance is exactly equal to the front occupied by B. From the front rank of B to that of C the distance is exactly equal to the "front" of C, and so on. If the column thus formed marches so as always to keep these distances, it will be able to form line again at once to the left of the column in the old order,

Fig. 3.—CHANGE OF FORMATION FROM LINE TO COLUMN, AND FROM COLUMN TO LINE.



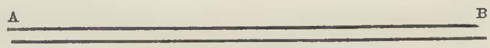
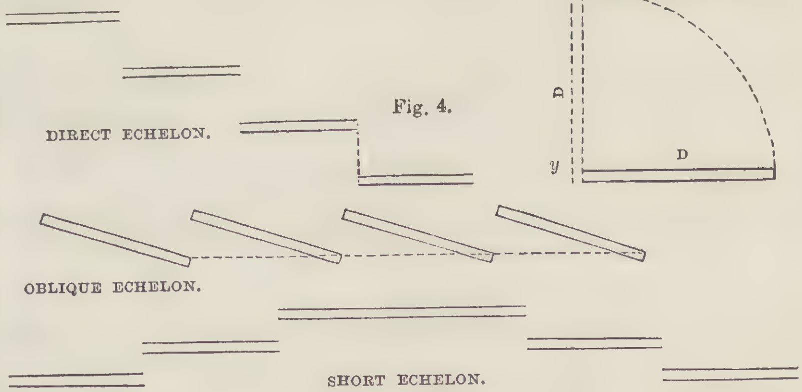


Fig. 1.—LINE.

Fig. 2.—THE OLD CLOSE COLUMN.

Fig. 4.



DIRECT ECHELON.

OBLIQUE ECHELON.

SHORT ECHELON.

by letting each part, A, B, C, D, "wheel on its own ground," as it is called; that is to say, that if the left of each part, A, B, C, D, remain where it is, merely slowly turning to its left, while the right sweeps round along the dotted line, the whole will again be in line, and A on the right of the line as before, and D on the left. The column $x\ y$, which possesses this property and is arranged in this way, is called an "open column," or for brevity it is described as simply "column," all other formations in column having special names assigned to them. It is clear that a similar column might have been formed by placing the several parts of the line in the opposite order behind D instead of left when the right is in front, it is not at all convenient to do so if it can be helped. Similarly with a column left in front (*i.e.* in the order D, C, B, A), we can re-form line in the old order if each of the several parts wheel to the right. As long as we are on the march there is no inconvenience in having right or left in front. Therefore, by always placing in front the right or the left, according as we intend afterwards to form our line to the left or the right of the column, we can usually arrange to have this formation very adaptable to certain contingencies.

It will, however, be observed that the depth is very great, being in fact equal to the whole front occupied by B, C, and D,

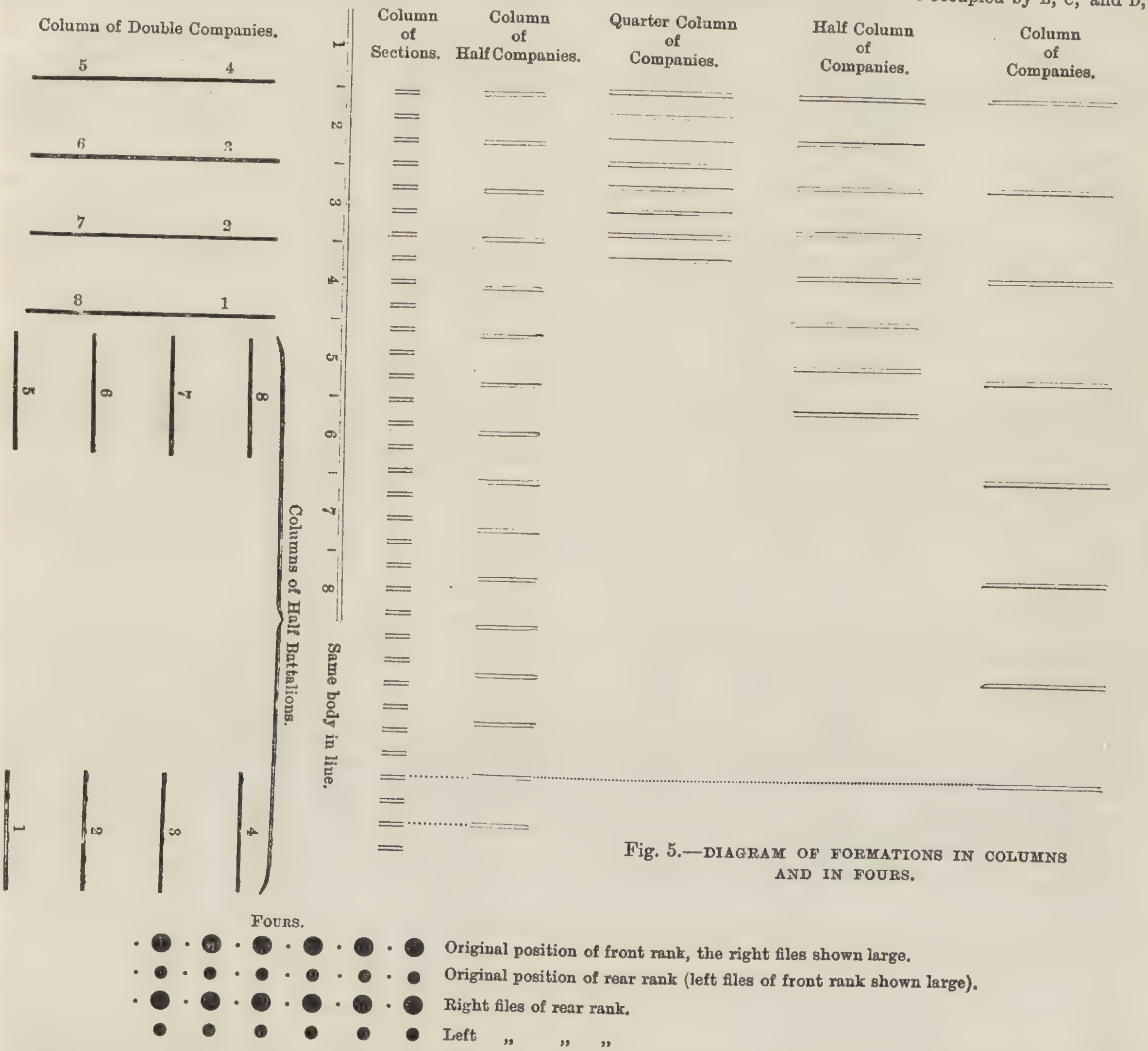


Fig. 5.—DIAGRAM OF FORMATIONS IN COLUMNS AND IN FOURS.

behind A; then D would have been in front, C next, and so on, A being in rear. The column with A in front we call a column "right in front," the column with D in front we call a column "left in front." It will be seen that if instead of letting the several parts each wheel to the left in the manner shown in the figure, where A is in front, we had allowed them each to wheel to the right, we should have no longer had D on the left of the line, but on the right of it. So also A would no longer have been on the right, but on the left. The line thus formed would have been said to be "inverted." We always number the parts of our line from right to left, and if we allow the right to become the left, such practical inconveniences ensue from the inversion that we are obliged to change the order and number them off again from the right. Hence though we do, where necessity requires it, wheel to the right instead of to the or, as we may otherwise express it, by the length of the whole original line less the front of the leading part. If we want to form the line to the front instead of facing the right or left of the column, D has a long way to go in order to move into its place on the left. Moreover, in order that each body B, C, D may move into its place in line, specific orders have to be arranged, which may be given to B, C, D severally, in order that they may move in the quickest manner, and without interfering with one another.

A general order as to the nature of the movement to be executed by the whole body may be given by one commander; but each one of the several fractions will require to receive specific directions from a man who accompanies it, and who, at the moment when it requires to change its direction, will give it the required order. For such a drill as this, then, it will be suffi-

cient if we form together as one whole bodies large enough, when in line or when broken from that into column, to be able to hear the orders of one man. The body thus formed will require to be broken up into as many parts as convenience may suggest. The size of the larger body is, in fact, determined by the convenient limits of the human voice. The body whose size has thus been fixed we call a "battalion." In all armies this has been reckoned much alike hitherto. Where a difference in the size of battalions has existed, it has been because the troops of the larger battalion were, when in line, formed in three ranks instead of two. No army has attempted to place in the field, under one man's direct personal orders, a body whose front occupied in line more than about 800 feet. On the other hand, the number of "companies" into which the battalion has been broken up has varied very considerably. The Prussians have four companies in their battalion. We have eight. The size of the company is fixed rather by considerations of what is called "interior economy" than by those of drill. A company is, in fact, the largest body which one man can conveniently, in accordance with the existing system, look after in all respects. It is the duty of a captain to attend to the order, comfort, and well-being of his men, with a degree of detail which no officer superior to him requires. The officer commanding the battalion issues orders as to the manner in which detail is to be carried on; but it is the captain who is personally bound to superintend its being carried out. The possible size of the company very much depends on the nature of the duties which are assigned to the subalterns. If the latter have to refer every detail to the captain, it is impossible that the captain should look after more than a very small number of men. If, on the contrary, the captain's duty is to see that his subalterns carry out his orders, but not to do their work for them, many more men can be placed under the orders of the captain. It will be necessary to recur to this question again. At present, so far as drill is concerned, it will be sufficient to note that, with one exception to be presently mentioned, all the drill in close formations consists in changes from different forms of cohesion into line, and from line back to these. In order practically to carry out these changes of formation, it has been necessary first to determine, by the careful experiment and report of committees appointed for that purpose, in what way each part of the battalion can best move so that the whole may most conveniently work together; and then to fix for each part of the battalion the words of command, which have to be given severally by the battalion commander and by each of the officers in command of companies. These orders have then strictly to be adhered to in the case of each movement, so that each part of the whole may learn to work with mechanical precision and rapidity when the word is given. These words of command are, in fact, laid down in the several drill-books of the different arms, and have to be learned by heart from them.

In order, however, practically to carry on the drill, the officer who conducts it has to acquire a good many other qualities besides those of mere accuracy of memory. He requires to give out his words of command in a clear, loud, unhesitating voice. He must keep under his eye the movements of every one under his orders. He must instantly detect where anything has gone wrong, see who it is that has made the mistake, immediately stop the movement of the whole, and have the error corrected. In training young troops, and even in perfecting older ones, if this is not done an error once committed tends to repeat itself, and the drill is mischievous, not useful. To be prompt in seizing upon the least blunder at the moment when the officer is himself watching to give the next necessary word of command exactly at the right moment, neither too slowly nor too hurriedly, needs much practice. It constitutes the difference between one who is known as a "good drill" and a bad one. It by no means ever comprised all the qualities which went to make up a "good officer;" but a good many of them are still practically involved in it. I propose here to name only the different formations. The words of command adopted are quite irrelevant to the purpose of these papers. An understanding of what the different forms are, and their purpose, is, on the contrary, essential to all that is intended to be explained in them.

Suppose that the body formed in line is now considered as a battalion, and that we suppose it divided into eight companies. I do not think it will be necessary for our purpose to speak in detail of the positions taken up by the officers during movement. It will be sufficient to say that the usual place for the captain is in rear of the centre of his company, but that he is not restricted to any particular spot, his duty being generally to look after the movement of his men. There are two "guides" for each company, properly the two subalterns of it, and there are two "markers," usually sergeants. The former see to the guiding and "dressing," or straightening of the company from the right or left, as the case may be. The one whose flank is not that from which the guiding is given is in rear of the company. The chief duty of the markers is to mark the points on which the flank of their company is to move. In line the colours are in the middle of the battalion. The diagram (Fig. 5) shows more clearly than a description what the characteristics of the different columns are. I have already described the nature of that on the right. It is a column formed with each company distant from the one in front of it its own length in line. The one next to it is also a column of companies; but the companies are half the distance apart from one another. The quarter-column is the formation which, from its greater compactness, is the one most employed when large bodies of troops are working together. In it the companies are not a quarter of their own distance apart—as might perhaps be inferred from the name—but six paces, or five yards. It is, in fact, more convenient for this, the closest formation we adopt, to fix definitely what distance apart the companies shall be rather than to allow the distance to vary with the length of the company. It is obvious at once that with neither the half-column or the quarter-column will a simple wheel of the companies be possible on their own ground. They would come up against one another. Therefore, in order to form line from quarter-column, we have to move in a different way. This brings us to the consideration of another and simpler kind of column, employed not only for the detail of manœuvring, but the ordinary form of movement in confined situations. A "column of fours" is so formed that it occupies in depth precisely the same extent that the line occupies in length. In originally forming fours the odd files from the right of the front rank remain on their own ground, only turning to the flank that is required. The rear rank steps back just sufficiently to leave room for the left or even files of the front rank between it and the front rank. The left files then form to the right or left of the right files of each rank according as the column is to be formed to the right or left of the original line. In order to regulate the movements, and make it certain that all bodies shall work in the same time, every soldier has to be trained to a fixed rate of march and length of pace. The pace in the ordinary quick time is 30 inches, and 116 paces are taken in a minute, making 3 miles 520 yards in an hour. In "double time" the length of the pace is 33 inches, 165 paces per minute, making 5 miles 275 yards in an hour.

It should be observed that the expression "double quick," often used by non-military writers, is a long since obsolete term which has no place in our drill-books.

There are various other matters, into the detail of which it is not necessary to enter, in which the individual soldier has to be instructed in order that he may be able to move with others in a precisely determined manner. Such are his turnings to right and left, to the right and left about, half left, half right, three-quarters left about, three-quarters right about, etc. Supposing this instruction acquired, it is obvious that by properly regulated words of command line can be formed from the quarter-column, and quarter-column from line readily in any manner that may be required. In addition to the three kinds of column already noted (column, half-column, and quarter-column), we have what is called column of double companies, and column of half-battalions. In the column of double companies the two centre companies are in front, the two nearest to the centre follow next at a distance of a length of a company from them, the others following in a similar order, as shown in the figure. In the column of half-battalions the column, instead of being practically single but of double-company front, is broken up into two columns formed on the left company of each half-battalion, as shown in the figure. The column of double companies is very convenient when it is intended to re-form line again to the front, when the ground admits of so wide a front for movement as that of two companies, and it is not necessary to shorten the column considerably. It should be observed, however, that this formation is only adapted for use in cases in which, when it is intended to form line, it will probably be con-

venient to extend the front on both flanks at the same time. In the columns of half-battalions the depth is the same as that in the column of double companies, but a less front is exposed to fire at any one spot, a less width is required for the movements of either column: to bring the line into its original order on re-forming for action it is necessary to form on the right of the leading company of each column.

So far we have considered only, except in the special case of the formation of fours, columns formed of some combination of companies. Other columns are, however, used, in which the smaller subdivisions of a company—namely, half-companies and sections—are the separate bodies which together form the column. A half-company is, as its name implies, the half of a company; a section is the fourth of a company, or half of a half-company. At present we only employ columns of half-companies and columns of sections for purposes of marching, the object of their use, in fact, being to enable us to have the largest front which the ground will admit of, in order, as far as possible, to reduce the length of the columns. For use in the manœuvres of battalions, and therefore of larger bodies, we do not employ these latter, but only the columns which have been already referred to. We have, however, another very valuable method of movement in close formation—viz., "echelon" (Fig. 4.) In this the several parts of the line are broken up, so that each moves, to some extent, independently. In the case of "direct echelon" as much fire is available to the front as in line. Both direct and oblique echelon have a property the full value of which can hardly be appreciated without going further into certain questions of tactics than would here be possible, but the simple advantage of which is obvious. It is clear that when a body of men are so arranged side by side as to be able to direct all their fire to the front, they cannot fire to their direct right or left, each man being in the others' way. The line must wheel, or some change of formation must be made, in order to bring fire in this direction. If the line is of great length, a change of front or of position is a very elaborate and difficult operation, especially if, as is usually the case, any part of the line has to be thrown back.

GREAT MANUFACTURES OF LITTLE THINGS.—XI.

SCREWS (*continued from page 118*).

BY CHARLES HIBBS.

THE introduction of the American machinery effected a complete revolution in the screw trade, not the least of the changes being the complete extinction of the smaller manufacturers, and the almost entire absorption of the trade by one large and enterprising firm, that of Nettlefold and Chamberlain. Very great improvements were made in the machines, and the original American plant has been superseded by one of English manufacture. The following extract from an article on the wood screw manufacture, written by Mr. Joseph Chamberlain, member of the eminent firm just mentioned, for the volume on "Birmingham, and the Midland Hardware District," will convey an idea of the perfection to which the processes have been carried:—"The wire having been headed by a machine, . . . the forged blanks are carried to the turning and nicking machine, and are placed in a hopper above the machine, from which they are taken one by one by a mechanical arrangement, which places them in the machine where the heads are first turned, then nicked, and lastly re-turned to remove the burr left by the nicking saw. The blank thus nicked and turned is then delivered by the machine into a bucket placed to receive it. All these operations are performed in one complete revolution of the machine, and the nicked blanks are thus produced in a single operation instead of requiring three, as they would have done in the old-fashioned machinery. They are next carried to the worming machine, and placed in a hopper similar to that of the turning machine. Thence they are fed into the machine, and a cutter is now passed along the blank often enough to produce a thread of the required depth, at the same time forming a point at the end; after which the screw is taken out of the machine, and, as in the case of the turning process, put into a bucket below it. The machines being self-acting, one woman can attend to many of them, whilst on the old principle one attendant was required to every machine. The work is also much lighter, as it is only necessary to supply the hoppers with blanks and to change the cutters from time to time as they become worn."

Among the advantages claimed by the same writer from the adoption of the new method are these:—"Healthier work-places, regularity of hours, economy of labour, increased demand, lower prices, and at the same time higher wages; in fact, the salaries of foremen in many manufactories now are larger than the average profits of small manufacturers formerly." With regard to the item of increased demand, a sufficient confirmation is afforded by the fact that on the premises of the firm alluded to, comprising three large mills worked by steam-power, the make is probably not less, upon an average, than 130,000 gross per week, more by 30 per cent. than the total make before the introduction of the machinery. More than 5,000 tons of wire are consumed annually, and the cuttings from the threads, or "soife," accumulate at the rate of four tons per day. The screws turned out from the machines, though some of them are only three-eighths of an inch in length—and small sizes form the bulk of the production—would, if placed end to end, reach from London to Liverpool in less than three days.

The manufacture of patent nuts and bolts has become an important branch of industry during the last few years. At the once famous London works an immense number of these articles are weekly produced, chiefly for railway work, fastenings for rails, and for carriage and wagon building, as also for ship-building and engineering work generally. By the patent machinery in use fifty to eighty nuts can be produced per minute, varying from a quarter of an inch to three inches in diameter, and of the most perfect form and structure. So exact are the results that all the parts produced of a given size are interchangeable, no matter at what date they may have been turned out. From 500 to 1,000 tons per week are produced at these works alone, an additional exemplification, if any were wanting, of the multiform application of the screw, and of its great importance as an article of commerce.

To enter on an exposition of the value of the screw as a mechanical power is unnecessary, as this has been already done in the series of papers on "Applied Mechanics," while the methods of constructing a helix and projecting a V-threaded screw have been detailed in the lessons on "Projection." Its advantages also are self-evident, and not the least conspicuous of these is its superiority over the ordinary nail as a means of attaching locks, bolts, brackets, and metal fittings of all kinds to wood, and even for attaching one piece of wood to another, if the removal of the piece attached may become a matter of necessity at any time. And here we may be permitted to enter a protest against the bad habit which most carpenters and joiners unfortunately contract, of putting screws into the mouth, or holding them between the lips and teeth, to keep them in a handy position for use as soon as the holes are bored which are intended for their reception. The consequence of doing this is that the screw more readily contracts rust, and its removal often becomes a matter of extreme difficulty. To ensure easy withdrawal at any time, the end of a screw should be dipped in grease, or smeared with it, instead of being put into the mouth.

Some years ago, an attempt was made to introduce a new kind of nail fashioned somewhat on the principle of the screw, that is to say, the nail, instead of being perfectly straight from head to point, was twisted so as to turn once or twice in its length, the edges of the sides forming a thread similar to the thread of the screw, but, of course, being extremely shallow. The form may be readily seen by tapping a nail at top and bottom with pincers, and turning them in contrary directions. The nail, however, contrary to expectation, did not find favour among those who use nails, and its manufacture, we believe, was soon abandoned. In driving the nail into wood, the screw-like shape that had been given to it caused it to turn once or twice, according to the extent of the twist that had been given to the nail. In extracting an ordinary nail with the pincers it is manifest that it will be so bent as to render it useless, unless it be straightened again, which involves more care and trouble than the nail is worth. In drawing the screw-shaped nail, however, it was merely necessary, after gripping the head, to pull the pincers, twisting them round at the same time, when the nail would be extracted in the same condition in which it was before it was driven into the wood, and without breaking the edges of the hole into which it had been driven.

TECHNICAL DRAWING.—LXXXVII.

DRAWING FOR METAL-PLATE WORKERS.

Fig. 632.—The subject of this study is a section of brass sash-bar of a very simple form, given as an application of geometrical drawing.

Draw the perpendicular A and the horizontal B C.

Next draw the horizontals D E and F G, and terminate them by the perpendiculars D F and E G.

Draw the horizontal line H I, setting off H I at equal distances from the central perpendicular. From the centre draw the outer circle meeting the horizontal in H, I.

From F and H and G and I, with radius F J, describe arcs cutting each other in J and K.

From J and K draw the arcs H F and I G, and from A set off on B C the distances L and M. Draw D L and E M.

Draw the horizontal N O, and the arcs L N and O M, which will complete the external form.

The inner line is parallel to the outer one, and is drawn in the same manner.

The section lines are of course drawn by the aid of the set-square of 45°.

Fig. 633.—This is another exercise of accurate drawing similar in character to the last.

Set out the horizontal lines as in the previous figure, and find the points A, B, C, D.

Draw A B and C D, and bisect these lines in E and F.

From A and E describe arcs cutting each other in G, and from E and B describe arcs cutting each other in H.

From H describe the arc E B, and from G describe the arc E A, carefully observing that these arcs must meet with the utmost accuracy without overlapping. This practice has been shown in the construction of the Cyma Recta moulding in "Drawing for Stonemasons."

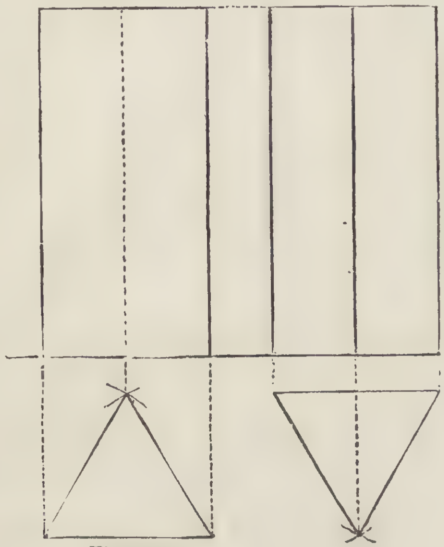


Fig. 636. Fig. 637.

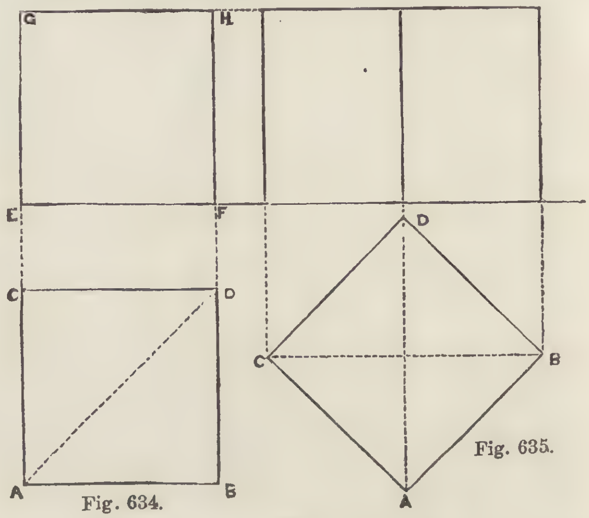


Fig. 634. Fig. 635.

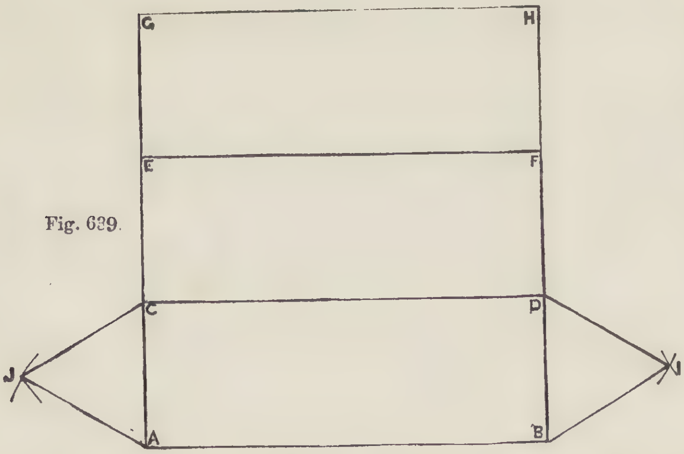


Fig. 639.

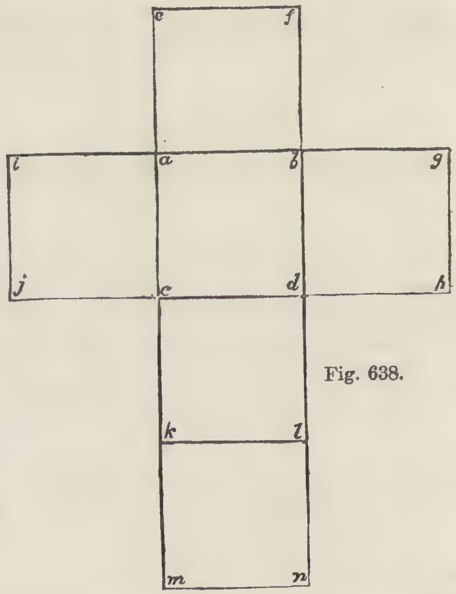


Fig. 638.

We now proceed to the application of some of the principles of projection and development, as specially applied to the present branch of industry; assuming, as in the case of "Practical Geometry," that the student has made himself thoroughly acquainted with the general principles of the subject from the lessons already given.

Fig. 634.—A B C D is the plan of a cube, and E F H G is the elevation, which in the present position of the cube is the same shape as the plan. For it will be evident that since the cube consists entirely of squares at right angles to each other, the piece of ground the object stands upon must be a square, and also that the side standing on A B is parallel to the vertical plane, and hence its elevation is the square E F H G.

Fig. 635.—In this study the object has been rotated so that

one angle, A, faces the spectator, and thus in the elevation two sides are visible, neither of them, however, appearing of its real width, whilst the height remains unchanged.

Fig. 636 is the plan of a triangular prism, the one face of which is turned towards the spectator, and thus, as it is parallel to the vertical plane, the elevation is simply a rectangle.

Fig. 637 shows the same prism when turned round, so that the face parallel to the vertical plane is at the back, and one edge facing the spectator; the elevation is thus two rectangles, the boundary line, however, being the outline of the rectangle, which is parallel to the vertical plane.

It has already been said that an object apparently solid is not

Fig. 632.

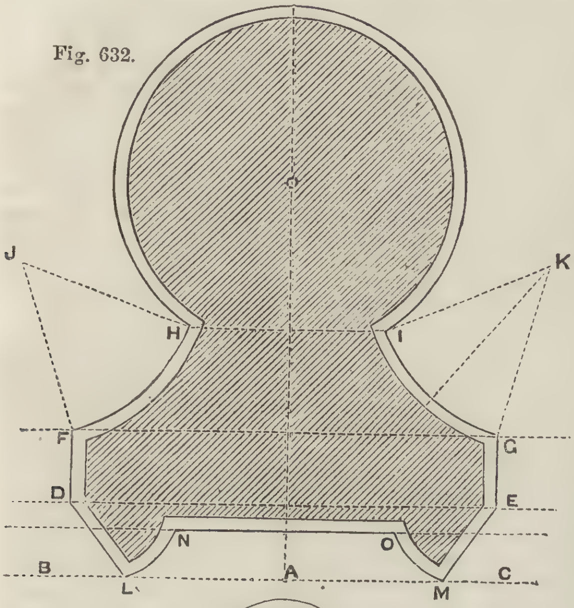
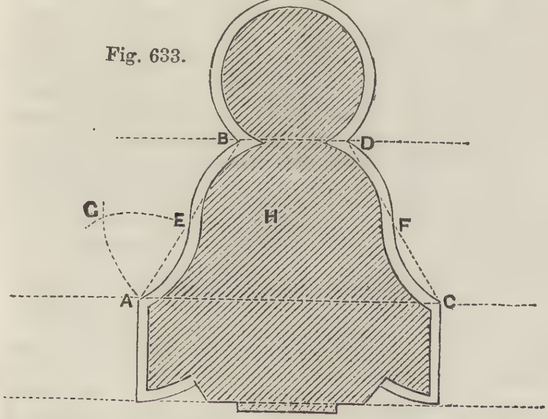


Fig. 633.



necessarily so, and it is a most important part of the work of the metal-plate worker to know the exact shapes into which metal is to be cut, so that when riveted, bent, or otherwise united, the object may be formed.

This portion of the subject is called development of surfaces.

We will in the first instance show the method of developing a cube.

Construct the square *a b d c* (Fig. 638), representing the base or any one side of the cube. Produce the sides of this square to *e, f, g, h, i, j, k, l*, and construct the squares *a e f b*, *b g h d*, *d l k c*, and *c j i a*.

At *k l* (or any other of the external lines) construct the square *k l n m*, which will complete the development, for it will be seen that if the squares *a e f b*, *b g h d*, *d l k c*, and *c j i a* were bent upwards, they would form four walls of a box, of which *a b c d* would be the bottom, and that the square *k l n m* would fold over and form the top or lid, parallel to *a b d c*.

Fig. 639.—In this figure is given the method of developing a triangular prism.

It is clear that this object consists of three rectangular faces and two triangular ends. Therefore draw the rectangles A B D C, C E F D, and E G H F, and at the ends of A B D C draw the equilateral triangles A C J and B D I, which will complete the required figure.

ENGLISH CARRIAGE-BUILDING.—IV.

BY A LONDON COACH-BUILDER.

CARRIAGE PAINTING (*continued*)—PERMANENT WOOD FILLING—PREPARATION OF BODY—FINISHING—GRINDING PIGMENTS—VARNISHING—LINING AND TRIMMING.

In resuming our directions for carriage-painting, it is worth while noticing here that a material has recently been brought into the English market, called "permanent wood filling," which is confidently recommended as effecting a saving in time, expense, and labour, and withal more certainly closing the pores of the wood than the ordinary filling now in use. This invention is due to a Polish exile, named Piotrowski, who took refuge in America, and there first introduced it in 1867, since which date it has found its way into the principal carriage factories of the United States. It is applied to the bare wood, one coat being given to bodies, and two to carriage parts. This closes the pores, holds the grain immovably in its place, and is so permanent in its effect, that neither exposure to dampness nor atmospheric changes, nor the vibrations to which a carriage is so subject, can act upon the grain. The satisfaction which this material appears to have given to our transatlantic cousins—who pride themselves upon the superiority of their carriage-painting—ought to induce our English coach-builders to inquire after it, for if all that we hear of it be correct, it must assuredly be a valuable acquisition in the paint-shop.

But, following the receipt given in our last paper, the body now receives a staining coat, after which it is well rubbed down with pumice-stone, and brought to a perfectly smooth surface. It is then carefully cleaned off, and receives two coats of dark lead colour made of tub lead, lamp-black, raw oil, and a small quantity of sugar of lead, and reduced to a proper consistency with Japan gold size and turpentine. One coat of this is applied per day, and after each coat the panels should be rubbed with fine sand-paper, and cleaned off. The dark surface that is now presented gives the painter a fair chance of seeing any scratch or imperfection that may be left on the panels, and which requires stopping up. After this has been attended to, the body is carefully faced down till a fine even surface is produced. Another coat of dark lead colour, the same as the last named, is then applied, and the body is ready for the ground colour.

Below we give a synopsis of the foregoing, that the painter may have a concise view of the entire process:—

PREPARATION OF BODY FOR COLOUR.

1 priming coat of lead (or leather parts, two coats of black varnish instead).
2 thin coats of colour. Stoppered up.
5 coats of filling-up (8 coats on leather parts).
1 staining coat. Rubbed down and cleaned off.
2 coats dark lead colour. Stoppered up. Rubbed down carefully.
1 coat dark lead.

12 coats, and ready for colour.

In the carriage parts two priming coats are first applied, which are worked the same as those used in priming the body. The cavities are then stopped with hard stopper, to which a little turpentine is added, in order to make it sand-paper easily. The wood parts then receive two coats of quick-drying lead colour, instead of dry lead and lamp-black ground in Japan gold size, and thinned with turpentine. The whole is then sand-papered down thoroughly, and the grain will be found to be well filled and perfectly smooth. A thin coat of oil, lead colour, is then added and well sand-papered, and any joints or open parts between the tire and felloes of the wheels are carefully puttied up with oil putty. The carriage parts are then ready for colour. Below is a synopsis:—

2 coats of lead priming. Stoppered up.
2 coats of lead. Sand-papered thoroughly.
1 thin coat of lead colour. Sand-papered and puttied up.

5 coats, and ready for colour.

To finish the body, we must proceed as follows :—

For the upper quarters and roof we must grind ivory black in raw oil, stiff, and add a little sugar of lead very fine for a drier, and thin to the required consistency with black Japan and turpentine. We must apply two coats of this, and then give two coats of black Japan, and rub down. Then face off the mouldings, and give a thin coat of dead black, after which apply a second coat of black Japan, and flat again. The whole should then be varnished with hard drying varnish, flatted down, and finished with a full coat of wearing body varnish.

If the body is to be blue, mix ultramarine blue with one-half raw oil and turpentine, stiff, and make of the proper working quality by thinning with hard-drying body varnish. Give the body two coats, and after each a slight flatting, then give two more coats of the same with varnish added. When Prussian blue is used, two coats are applied, and white is added if necessary, for the purpose of producing the required shade. The blues will dry sufficiently well when merely ground in raw oil, stiff, and reduced with turpentine, and it is better not to add any drier over blues, only one coat of hard-drying varnish should be given, and one finishing coat.

If the body is to be lake, the lake should be ground in raw oil, stiff, and reduced with turpentine and hard-drying varnish. The same with dross black and Indian red. Over lakes and greens two coats of hard-drying varnish should be applied, and one coat of finishing.

In no case should the painter allow his oil colours to dry with a gloss. He must always flat them, and give them the appearance of dead colour. This is particularly important in case rough stuff or quick-drying colour is to be used over it.

To finish the carriage parts, two coats of lead colour are first given, made the same as those given to the body before the application of colour. Then stopper-up with hard stopper, to which a little turpentine is added to make it sand-paper easily. Then give the wood parts two coats of quick lead, mixed of dry lead and lamp-black ground in gold size, and thinned with turpentine. The whole is next sand-papered thoroughly, when the grain will be found well filled and perfectly smooth. A thin coat of oil, lead colour, is next applied, and finally sand-papered, and at this point any joints or open parts between the tire and the felloes of the wheels should again be carefully puttied up with oil putty. A coat of colour varnish follows, then a second coat of the same, to which more varnish is added. All the parts are then flatted and striped, another light coat of clear varnish is given, and after being flatted down, the fine lines are added, and the whole is finished with a good coat of wearing varnish.

Such is the tedious process of painting, if we wish the work to be properly executed. In following all these details a great deal of time will be occupied, but the result will surely be satisfactory. In no case should the painting be hurried, for by allowing each coat of paint or varnish sufficient time to dry thoroughly before the next is added, the quality of durability is ensured. But in laying down these rules for carriage-painting, we have said nothing about the manner of producing the different colours. This is an art of itself, with which few coach-painters are acquainted. As a rule, they know little or nothing of the chemical qualities or affinities of the pigments they use; and for the production of the beautiful hues and shades which adorn the panels of our pleasure carriages, they are almost entirely dependent upon the manufacturer. While such is the state of knowledge in this branch of industry, it is to be regretted that the manufacturer can devise no better means than to give the material raw into the hands of the painter. Indeed, under any circumstances, it would be better if he could offer his goods ready for use; for in the process of grinding, the heat generated between the stone and the muller will often materially damage the hues of the delicate colours, and must, to a great extent, affect most of the pigments. Moreover, a great amount of time is expended upon an occupation that does not properly belong to the painter, and, in meting out quantity, a good deal of waste must necessarily be occasioned. To lessen the labour in this department, hand paint-mills have been largely introduced into our carriage factories. This is a step in the right direction, and has produced great advantages; but whether the grinding of colours is effected by stone and muller or by the improved paint-mill, the process is anything but cleanly, and the disagreeable effects of it are too patent to need much comment; and the painter constantly, for fear of providing himself with too little, very naturally prepares too much. It is objected, however, by our manufacturers, that colours cannot be ground and preserved in a liquid form ready to the painter's hand; but we learn from across the Atlantic that American invention has accomplished that which baffled English ingenuity, and that in New York pigments of every shade and hue are being so supplied, and with complete success. Mr. Masury, of that city, has produced machinery which enables him to grind pigments, even of the hardest description, to the most impalpable fineness, without in any way detracting from their purity or delicacy of hue, even when these are the most evanescent; and, by a process of his own, he preserves them so that the painter has nothing to do but to reduce them to the proper consistency and apply them to his work. We are at a loss to understand why so valuable an invention is not introduced into this country.

Another important question in relation to this department is that respecting varnish. After a coach-builder has exercised the greatest skill and care to produce and paint a carriage in the best style, it is no uncommon circumstance for him to see his finished work marred by the freaks of varnish, even when that material has been obtained from the best makers, and every care and precaution has been taken in the use of it. What is still more singular is, that varnish from the same can, in the hands of the same workman, will not always turn out equally satisfactory. These peculiarities have largely occupied the attention of the trade, and every variety of explanation has been given concerning them, but all these may be summed up in the one term, "atmospheric influence."

It may be very interesting, and even in some cases useful, to know that dampness of the varnish-room, the approach of a storm, the state of the atmosphere, mixing or otherwise tampering with varnishes, will cause them when used to go off in silky streaks, to pin-hole, to spot or to bloom; but there can be no solid advantage gained unless we can ascertain—why? When this question can be answered correctly it is quite possible we may arrive at prevention as well as explanation.

The defects of varnishes should be divided into classes—namely, those which exhibit themselves in the varnish-room before the carriage is pronounced finished, and those which occur after it has passed into the hands of a customer and beyond the control or experience of the builder. The defects which show themselves in the varnish-room are those of "spotting," "blooming," "pin-holing," "going off silky," "going in dead." Those which take place afterwards are "cracking," "blooming," "mud-spotting," and rapid loss of surface and impoverishment, sometimes amounting to absolute destruction.

These two classes should be considered separately, and assuming, as it is necessary to assume in such a case, that the workman who has executed the work is well skilled, and the varnish used is of the best quality, we should unhesitatingly dismiss this latter class of defects as not necessarily attributable to the varnish, except in the single case of blooming, which, as every one in the trade knows, arises from the atmosphere being overcharged with moisture, and is therefore only of temporary inconvenience. The best elastic varnish will crack from too great exposure to the sun, just as anything else may sustain injury from unfair treatment; the mud-spotting will arise from using the carriage in muddy or slushy roads before the varnish is sufficiently hard; the loss of surface will depend largely upon the coachman, who, from negligence or ignorance, may easily flat-down the panels of a carriage till the looking-glass surface entirely disappears; and impoverishment and destruction of varnish will commonly arise from the coach-house and stable being contiguous, the ammonia rising in steam from a stable being the most destructive chemical that varnish can be exposed to.

The other defects belong to the inherent nature of the varnish as at present manufactured, and, admitting the secondary cause to be atmospheric influence, it is necessary to inquire why it is that varnish should be subject to such influence. We do not pretend to penetrate the secrets of the trade, but according to the usual processes of making varnishes, we know that various metallic salts and chemical compounds are employed to increase their drying properties. All these will contain a certain definite amount of water, termed "water of crystallisation." If deprived of this water they lose their crystalline form, but they acquire a tendency of again assuming it, by attracting to themselves a proportionate amount of water whenever it is brought within

their influence. Now the heat employed in the manufacture of varnishes is sufficient to expel this water of crystallisation, and to cause these salts to become either dissolved or so thoroughly intermingled with the varnish as to have the appearance of a solution. Their presence is, however, sooner or later detected, for when the varnish is applied to the work the salts generally absorb the moisture which is always present more or less in the atmosphere to which they are exposed, and by becoming partially crystallised, cause what is known as "blooming," "spotting," and "pin-holing." The tendency to bloom will always remain, even after the varnish is thoroughly hardened, as we very well know; but if any one of these effects take place in the varnish-room while the varnish is drying, it is fatal to the appearance of the carriage. It follows, therefore, that if some substitute could be found for these objectionable dryers, not liable to atmospheric influence, we should get rid of these defects. Attempts have been made to substitute ozone or electrified oxygen gas, which has been largely introduced into many manufactories for its bleaching qualities, and is known also to possess peculiar properties as a dryer. After an article has been varnished the process of solidification to which we unphilosophically apply the term *drying*, is carried on by the absorption of oxygen gas from the surrounding atmosphere, and when the varnish is thoroughly hardened it has absorbed all the oxygen it is capable of, and the result is a beautiful transparent glaze. If these fine varnishes could be impregnated with oxygen in the course of their manufacture, their drying qualities would be facilitated without the use of the objectionable dryers now in use. It is found that they can be so impregnated with this gas in the form of ozone, but though experiments have been tried and favourable results produced, we are not aware that considerable success has yet been obtained, although we look to this discovery as offering great promise for the removal of the most tiresome and the most perplexing defects in varnishes.

We now come to the lining and trimming department, which is one also requiring great taste as well as skill. The interior of a carriage should be lined with cloth and silk, or cloth and morocco, with laces specially manufactured for the purpose; the colour should correspond to or harmonise with the painting. Light drab or fawn colour linings used to be very general for close carriages, such as broughams, because they at once afforded relief to and harmonised with any dark colour that might be selected for painting. But a severer simplicity of taste has prevailed of late years in this country, and the linings of carriages are mostly dark in colour, to correspond to the colour of the painting. This is often carried to such an extreme as to present an appearance of sameness and tastelessness. It is no uncommon thing, for instance, to see a brougham painted dark-green, striped with black lines, and lined with dark-green cloth and morocco, with plain laces to correspond. This, to us, appears only one degree removed from a mourning-coach, and we should be very sorry to see such a sombre taste prevail. On the other hand, we should pronounce violent contrasts quite contrary to all principles of good taste. Morocco and cloth, or silk and cloth, of the same colour as the painting should be selected for the lining; but as the painting should be relieved by lines that harmonise with it, so should the lining be relieved by the laces and tufts which are intended to give character to it.

SHIP-BUILDING.—XXV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

METHODS OF LAUNCHING SHIPS—CONCLUSION.

In this, the concluding paper of our series, we propose to describe briefly some of the most common methods of launching ships, two of which are illustrated by Figs. 64 and 65. It is the termination of the work of the ship-builder, and vessels are often sent afloat before the boilers are placed in the hull, as in the case of steamers, or the masts are put in their places and the necessary rigging put up. It is generally a gay scene, owing to the preparations for the ceremony of naming the vessel. The operation of launching may be simply described as the sliding of the ship down one or more inclined planes into the water; but in the construction of these inclined planes, or "launching ways," and in the transference of the ship's weight to them from the blocks, very great care is required in order to ensure success. This will appear more clearly if we consider any particular plan, say that illustrated in cross-section by Fig. 64.

The blocks upon which the keel of the ship rested during her construction will be seen to have been removed, and the ship is now resting on two supports, one on either side of the middle-line. The blocks A, A are placed very closely, and carry a planked covering, S S, the two forming what is termed the "ground-way" or "sliding-way," which is continued out far enough in most cases to make the vessel "water-borne" aft when the stern has passed a moderate distance beyond the ways. The inclination of the sliding-ways is usually about seven-eighths of an inch to a foot, or rather more than that of the blocks upon which vessels are built; their upper surfaces are very often slightly curved or "cambered" instead of being true planes. Before the vessel can be supported upon these sliding-ways, the strong timber-constructions termed the "cradles" must be fitted (as shown) between the bottom of the ship and the sliding-way. These cradles stretch over something like two-thirds of the vessel's length, and, of course, move with her when she is launched. Their main features consist of a large timber (B), known as the bilge-way, resting upon the sliding-way; and of what may be termed the cradle-proper, extending between the bilge-way and the ship. In the amidship part of the ship the distance between the two would, of course, be small, and it is usually filled in solid with timber, known as the "stopping up" (which may be supposed to be nothing more than C enlarged). Forward and aft, where the ship becomes finer, it is preferable to use numerous timber struts, or "poppets" (P P), between the bilge-ways and the ship, and to connect them by suitable planks nailed to the sides of the poppets, as roughly indicated in the sketch. Means have to be taken also to keep the heads of the poppets firmly fixed in their proper positions, when the enormous weight of the ship is brought upon them.

The bilge-ways are usually about one-third of the extreme breadth of the ship apart; and the whole of the arrangements described above are fitted in place while the ship continues to rest upon the blocks and the shores. The ribbands, R R, are secured to the sliding-ways, and strongly shored to the sides of the ship, in order to prevent the bilge-ways from moving further apart when the weight of the ship is brought upon them; and short shores are fitted between the bilge-ways and the keel for the purpose of preventing any closing in of the bilge-ways. Care must be taken in proportioning the surfaces of the bilge and sliding ways to the weight of the ship to be launched, and in all cases these bearing surfaces should be well greased not long before the launch takes place.

When the "launch" or "cradle" has been fitted, the pieces are separated, and the bilge-ways are taken out of place or "turned out." After the operation of greasing the ways has been finished, the bilge-ways are "turned in," and the cradle is re-erected and secured in place; this is usually done on the day before that fixed for the launch. Next, it is necessary to transfer the weight of the ship to the cradle; this is done by "setting up," or driving in wedges between the bilge-ways, B, and the timber, C, thus forcing the cradle tightly up under the bottom. The blocks and shores can then be removed, but it is not customary to complete this part of the work until the time immediately before the launch.

When completed, the ship is held in position only by the "dog-shores," which commonly consist of short lengths of timber placed in an inclined position, heeled against the fore-ends of the ribbands (R, R) on the sliding-ways, and butted against cleats strongly bolted to the sides of the bilge-ways. At the moment of launching the fore-ends of the dog-shores are knocked down (by the fall of weights or other means) clear of the cleats, and the vessel is left free to move. Sometimes there is a difficulty in making her start, and then her motion is aided by means of hydraulic presses, shores, etc. etc., applied against the stem. In other cases, ships have stopped on the ways, sometimes in very awkward positions, straining the hulls severely. With these occurrences, however, we have no concern, and we shall assume the launch to be perfectly successful, the vessel gradually moving down the ways with an increasing velocity, until her stern enters the water, and quickly becoming water-borne aft before the bow is clear of the ways. When

there is plenty of room, vessels are allowed to go free, until their motion is checked by the resistance of the water; but when launched into narrow creeks or channels, other means must be taken to "bring them up" within the limits desired.

The cradle, of course, may be expected to detach itself, and to rise to the surface when the ship is afloat, but care should always be taken that no parts of the launch—such as poppets, etc.—remain under the bottom. In the case illustrated by Fig. 64, there would be some pieces actually fastened to the bottom to secure the heads of the poppets, and to remove these the vessel must be placed in dry dock. Many merchant vessels, however, are completed before being launched, and proceed on service immediately after, so that it would be impossible to carry out the plan of Fig. 64 in its entirety. A simple device suffices to meet such cases, for the cradles on opposite sides can be efficiently secured by means of chains passing underneath the keel, without attaching any pieces of plank to the bottom.

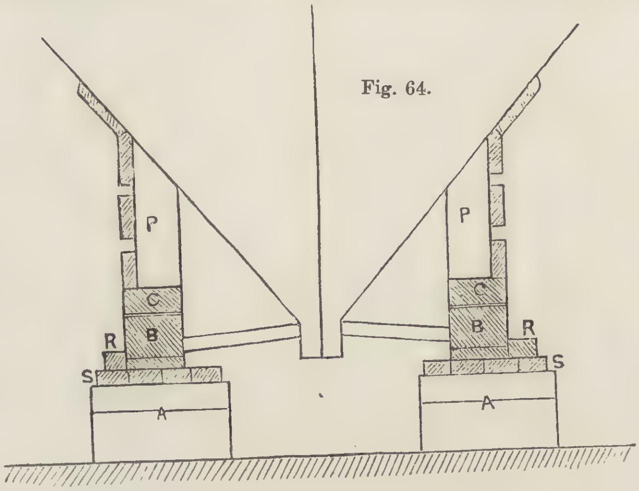


Fig. 64.

Another method of launching is shown in Fig. 65, and needs but brief description. It requires only a central sliding-way under the keel, the piles G, G, G being fitted not for the purpose of supporting the vessel, but in order to prevent her from falling over on her side when being launched, an occurrence that is not uncommon when precautions are not taken. Hence the upper surfaces of G are not fitted closely against the lower surfaces of H H, but are at a little distance from them. The method is said to answer well, and it is less expensive than the preceding, as the timbers H, H are all that need to be specially fitted to a particular ship, and the remaining pieces can be used for all ships. The French have long made use of this plan of launching on the keel; but in the Royal Dockyards of this country, the method illustrated by Fig. 64 is universally adopted.

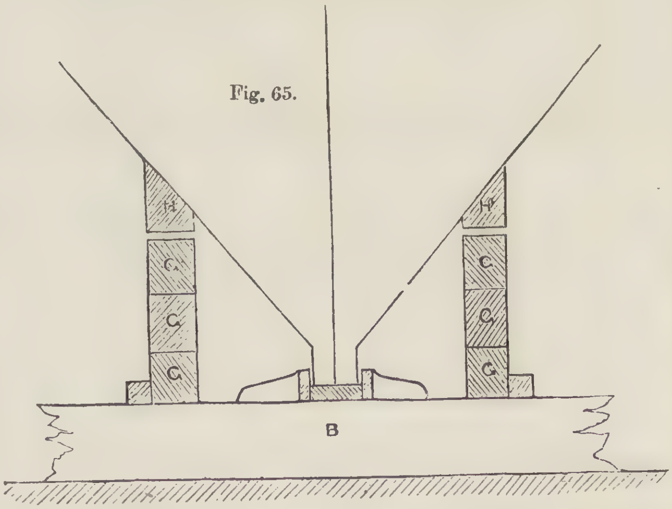


Fig. 65.

All the foregoing remarks apply to the commonest cases of ships built end-on to the water. When ships are launched sideways into the water, the sliding-ways are often made more numerous, and special forms of cradles are constructed clasping the ship transversely. This was the principle adopted in launching the *Great Eastern*. There were two broad sliding-ways, and an equal number of cradles; only in that case, instead of having the bearing surfaces of the launching ways of wood, and greasing them on the usual plan, there were iron bars bearing on iron bars. To this departure from the common plan, and the consequent decrease of the area and change in the character of the bearing surfaces, the failure of the first attempts to launch the vessel, and the great difficulty experienced in getting her into the water afterwards, are probably attributable.

In concluding these papers on Ship-building, we would remind our readers that only the main features of the subject have been considered, it having been impossible within the limits assigned to enter into details on any of its branches, or even to mention some important matters intimately associated therewith. For example, the *processes* of ship-building, involved in the preparation of the various parts of a ship, have not been touched upon; although they include the methods of "taking account of work" (to use a shipwright's phrase), the construction and use of moulds, the shaping of frames, beams, planks, plates, etc. etc., and many other features of interest. Nor have we been able to describe the qualities of the materials used in ship-building, the modes of testing their fitness for use, the special requirements for particular services, and similar points of importance. Then, too, the question of "laying-off" has been merely mentioned, although it is a most extensive one, and involves the whole practical geometry of ship-building. And if other instances were needed of the unavoidable incompleteness of our treatment, many might be given.

Throughout, our aim has been to supply some knowledge of the principles which underlie all proper ship-construction, as well as to illustrate the principal structural arrangements of various classes of ships. So far, we trust, we have not been unsuccessful; and at least it may be said that the information given includes many of the most recent and improved methods of building ships. The information which we have not had the opportunity of furnishing here can be obtained by those persons desirous of acquiring it from the extensive treatises on practical ship-building, in wood, iron, and steel, now accessible; wherein will also be found detailed descriptions of many arrangements of which we have only given the outlines.

From the preceding papers it will have become obvious that the knowledge required by the ship-builder is most varied and extensive, including not merely the principles of structural combination, but also an acquaintance with chemistry, galvanism, and many other branches of physical science. It will also have appeared that many and great improvements have been introduced within the last twenty or thirty years, and that other important changes seem close at hand. These improvements become more remarkable when it is considered that they have almost entirely originated with British ship-builders, and have had a great effect on the relative standing of both our mercantile and war navies, as compared with those of foreign nations. Our supremacy on the seas is of vital importance; it involves our keeping the lead in all branches of ship-building, and the applications thereto of the allied arts and sciences. At the present time our lead is probably greater than it has ever been. To retain this superiority will doubtless require an effort as years pass by, and other nations benefit by our experience and example; but so long as the disposition of our ship-builders to advance both in the theory and practice of their profession continues strong, there seems little reason for fearing competition in this great branch of the national industry.

MINING AND QUARRYING.—XXXIII.

BY GEORGE GLADSTONE, F.C.S.

COBALT.

DISTRIBUTION — ORES — OXIDE OF COBALT — USES — MANUFACTURE OF SMALT AND ZAFFRE—THEIR USES—THENARD'S BLUE.

THE two metals to which the reader's attention is invited in the present article do not occur to any great extent in the British Isles, but their uses are of sufficient importance to call for a brief notice of them. Some of the ores, moreover, which contain them are imported into this country in the raw state, and here prepared for use.

Cobalt is found at times in Devonshire and Cornwall, in mining for tin and copper, and in the cupriferous rocks of Alderley Edge, in Cheshire, and of some parts of Ireland. It is generally in combination with arsenic or sulphur, as arsenical or cupriferous pyrites, and is not very easily detected by its external appearance; so that there are well-authenticated instances of cobaltiferous ores having been thrown aside as worthless by those miners whose scientific education did not extend beyond the most ordinary requirements of their calling. A remarkable case of this kind occurred at the Mucross copper mines in Killarney, where a valuable ore of cobalt, which was abundant there, was rejected as rubbish, and one of the miners, who was wiser than his masters, managed to secure for himself a quantity of this rejected stuff.

Nevertheless, it can be infallibly detected by the use of the blowpipe, on fusing any of its compounds with borax for a few moments, when a beautiful and characteristic blue bead will form on the loop of platinum.

The ores of greatest importance occur in Saxony, Silesia, Bohemia, Norway, and Sweden; and it is in these parts of the Continent that the largest and most important works for converting them into a commercial article are found.

The metal itself does not occur in nature, and can only be reduced with difficulty from its ores. Moreover, it is of no economic value in its metallic state. No attention is therefore given to reducing it to this condition; the object of the metallurgist being to produce the oxide and the silicate, which are the compounds of greatest value in the arts. There are some other salts, such as the nitrate, phosphate, chloride, and sulphate, which have a limited application.

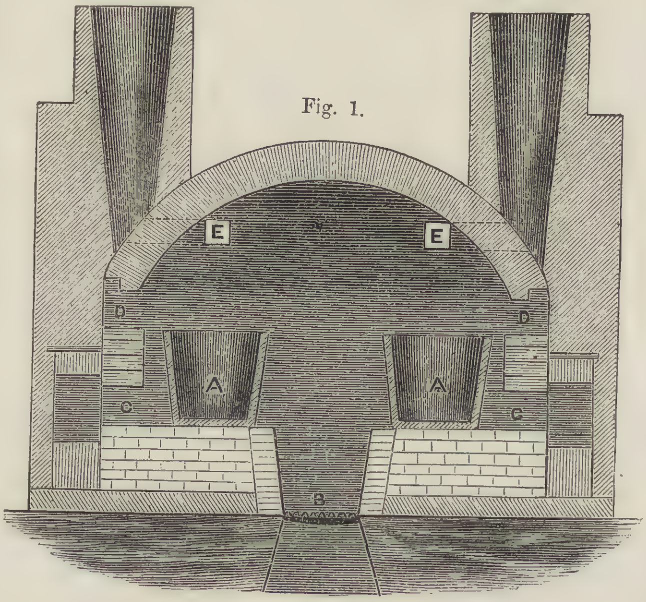
The oxide of commerce is prepared by smelting the ore, after separating by hand as much of the matrix as possible, and then calcining the regulus which is thus produced. On being withdrawn from the furnace, the calcined article is dissolved in hydrochloric acid, and the iron and arsenic contained in the solution are subsequently precipitated by the gradual addition of milk of lime. The sulphides are next thrown down by passing sulphuretted hydrogen through the solution, and the liquid then remaining is drawn off, and the cobalt is precipitated from it by the addition of chloride of calcium. The hydrated oxide of cobalt which is thus obtained is then submitted to a red heat, when what is known as the blue oxide is produced; or to a white heat, the product of which bears the name of prepared oxide.

These are used by potters to a considerable extent, for giving a bluish colour to their manufactures. A superior article, used in enamelling and in the best class of goods, is made by boiling up the raw ore in nitric acid, which causes the arsenic usually present in the ore to combine with whatever other metals there may be mixed up with it. These arseniates being all less soluble than the arseniate of cobalt, can be thrown down in succession by the gradual addition of the alkaline carbonates; and the proper time to suspend the operation can be easily recognised by the rose colour yielded by the cobalt salt.

It is the silicate, however, which possesses the greatest commercial importance. The familiar name of it is smalt; certain qualities are known as azure and ultramarine, the former an indefinite, and the latter a misleading term; and these are again subdivided into ordinary, middling, fine, superfine, etc.; the differences between which can only be learnt by practice.

In the manufacture of smalt the first thing to be done is to separate from the ores the earthy portions, and those metallic compounds which do not contain cobalt. The ores are therefore reduced to small pieces, and well picked over; they are then ground fine and washed, which separates the earthy matters, but leaves all the mineral constituents as they are usually of equal specific gravity to the cobalt compounds. The result is generally of very mixed composition, containing iron, copper, tin, or any other of the metals common to the district where the ores were raised. The next step of the process is to convert the levigated ore into an oxide, and at the same time to separate those metals which may be associated with the cobalt, or to reduce them to such a condition that they shall have no power to destroy the beauty of the blue colour, upon which the value of smalt depends. This is done by roasting it in a reverberatory furnace, the only special features of which are the long flues, which are made first to encircle the furnace, and then to pass into a long, wide gallery, sometimes called the poison chamber, where the arsenic of the ores, which has been converted into arsenious acid, is gradually deposited. The quantity of this poisonous substance is usually very large, as many of the ores contain from 45 to 75 per cent. of arsenic; and it would be both wasteful and injurious to the health of the workman if this were allowed to escape into the air. In Germany the roasting is generally performed in winter, as the cold favours the deposition of the acid. The roasting should not be carried so far as to drive off the whole of the arsenic, because in that case there is a danger of some of the other metals becoming oxidised, which would interfere with their ultimate separation.

Fig. 1.



The next thing to be done is to convert this roasted ore into a silicate. For this purpose it has to be fused with the ingredients necessary to constitute a glass, and the fusion should be so conducted as to remove the useless or objectionable ingredients in the dross. Potash is always used as the flux, as lime, soda, and magnesia all impair the richness of the blue colour. It is calcined prior to use, to purify it, and to drive off all the moisture which it may have absorbed. The quartz used has also to be carefully purified, for which purpose it is heated to redness, pulverised, and then washed and re-heated. The relative proportions of ore and quartz which should be used are determined by trials on a laboratory scale, and one-third of their united weight will be the quantity of potash to add; to these must also be added some arsenic about equal in weight to the ore. This last ingredient is used just in the condition in which it is taken from the galleries already described, where it

is deposited from the roasting. These materials are well mixed together in troughs, and from them the mixture is transferred to the pots in which it is fused.

The melting pots are carefully made of refractory clay, and thoroughly dried and annealed before use, as they will have to bear an intense heat. The interior surface of the pots is glazed with an inferior quality of smalt. They are set in a furnace somewhat similar in construction to that of a glass-house. The accompanying diagram represents the cross-section of a round one, with two of the pots in their place. These are marked with the letters A, A, and there are usually eight of them in each oven. The fire-place, B, is in the centre below the floor, and is fed from the outside; the draught passes up from the ash-pit, and carries the flames up into the vaulted chamber. C, C are called knee-holes, which are opposite to a small opening near the bottom of each pot, which is closed up during the melting, but through which the contents are withdrawn when the operation is complete. The working holes, D D, are at a higher level; through these the charge is introduced, and the mixture stirred occasionally during the melting with a red-hot poker. Sometimes also the glass is withdrawn through these in iron ladles. The waste gases pass out through the flues E, E, into the chimney. The knee-holes are kept closed until the fusion is complete, and the working holes are only opened for inserting the charge and stirring it during the melting; as soon as this stage is reached they are kept closed, and the furnace maintained at a full white heat for some time, to produce a perfect combination of the ingredients, and to allow the impurities to separate themselves. On the surface a little sandiver generally collects, which has to be skimmed off; and a compound called speiss, consisting of various impurities, sinks to the bottom. If the glass is ladled out through the working-holes, the workman has to take care not to let the speiss get mixed up with the rest; if the pot is tapped the speiss flows out first, and is removed, and then the pure blue glass is allowed to flow into the bath prepared for its reception. The glass, immediately on its being withdrawn from the pots, and while yet red-hot, is thrown into cold water, the sudden cooling caused by which breaks it up, and renders it so brittle that it can easily be ground to powder. The speiss consists of an alloy of cobalt, nickel, iron, arsenic, bismuth, and sometimes other metals.

The grinding of the glass is conducted under water between two mill-stones; and after they have been at work for some hours, the water in which they have been revolving is allowed to run into a succession of receivers to settle. The purest smalt, being the heaviest, will soon sink to the bottom, and then the water is drawn off into the second receiver, where the next quality will be deposited, and so on until the whole of it is collected. The precipitates are subsequently washed thoroughly, to secure the greatest possible purity, and then packed in casks.

The chief use of smalt is in making blue glass, and in producing a deep blue design in porcelain, earthenware, etc. It is also used as a pigment, and for neutralising the yellowish tint which paper, linens, calicoes, and other articles would otherwise possess. Scientific investigators also often avail themselves of glass coloured by cobalt, as it cuts off the luminous rays of the sun to a great extent, without interfering with the rest of the spectrum.

Zaffre is also much used by the manufacturers of earthen and glass wares for producing a blue colour. It consists of a mixture of the roasted cobalt ore and flint, both ground to a fine powder, the relative proportions of which are so adjusted that they will produce a glass of a certain tint when fused with alkali. The various qualities and tints of both articles are known by the marks acknowledged in the trade.

Thenard's blue is a very beautiful colour which is also used to some extent. It consists of two parts of the phosphate of cobalt, and one part of the arseniate, mixed with sixteen parts of alum, and then burnt.

NICKEL.

GEOGRAPHICAL DISTRIBUTION — ORES — SEPARATION FROM COBALT SPEISS—FROM COPPER ORES—ALLOYS—THEIR USES—ELECTRO-PLATING—MAGNETISM—METEORS.

Nickel is found in still less quantity than cobalt in this country, though some small per-centage of it may often be found in copper and other ores. Germany and Austria are the great sources of supply.

The pure metal is ductile, and of a brilliant white colour: it is scarcely used except in its metallic state. It is derived from kupfernickel, which is a compound of this metal with arsenic; from nickeliferous pyrites; and from cobalt speiss, which usually contains a considerable proportion of nickel, as these two metals are very much associated in nature. It is from the latter article that this metal is principally obtained in this country.

The speiss is fused with chalk and fluor spar, and the product is then ground up and roasted to expel the arsenic. It is then dissolved in hydrochloric acid, and the iron and any arsenic still remaining in it is precipitated by the action of chloride of calcium and milk of lime. Sulphuretted hydrogen is then passed through the solution, which will throw down the other metals contained in it, with the exception of the cobalt and nickel. The former of these will be separated by the addition of some more chloride of calcium, and lastly the nickel in the state of an oxide by adding milk of lime.

It will be seen from what has gone before that both cobalt and nickel have a great affinity for arsenic, and from this last operation that they have very little for sulphur. Advantage has been taken of this circumstance in copper-smelting, as copper, on the contrary, has a strong affinity for sulphur, and only a weak one for arsenic. Mr. Vivian therefore introduced the plan of separating the small per-centages of cobalt and nickel which are frequently present in copper ores, and which impair the quality of the metal, by introducing a sufficient quantity of arsenic or arsenical pyrites, to convert the whole of the nickel and cobalt into arsenides, while the copper is converted into a sulphide. After being melted, the copper regulus will be found to overlie the arsenical compounds, which have then to be separated and purified.

Nickel enters into alloys with some of the other metals, producing compounds of very considerable utility. Some of these are known under the general name of German silver, which is largely used as a foundation for silver plating. It can readily be detected at the points of forks, or wherever the pure silver is exposed to rapid wear, by the yellowish shade of the alloy as compared with the other. The colour, however, varies according to the relative proportions of the metals of which the alloy is made, the best qualities being scarcely inferior in brilliancy to silver itself. Forks and spoons, and other articles of domestic use, are often made of such compounds without being subsequently plated; they also answer well for the manufacture of mathematical instruments.

The following table gives the per-centage proportions of various alloys of nickel, with the special characteristics of the several combinations:—

Nickel.	Zinc.	Copper.	Character of Alloy.
15	26	59	This is about the most inferior preparation. If a smaller quantity of nickel were used, the alloy would tarnish rapidly.
20	34	46	A compound common in China, called Tutenag. It is very fusible, but at the same time very hard. It rolls badly, but makes very good castings.
21	24	55	A good mixture, having the appearance of silver which is somewhat below the standard.
24	19	57	These proportions make an alloy which rolls well. If 3 per cent. of lead is added, it will be very suitable for castings.
25	25	50	A very suitable proportion for the usual plated goods.
26	23	51	A decidedly superior article. It closely resembles silver in colour and brilliance, and it is less liable to tarnish.
34	20	46	This is about the largest proportion of nickel that can be used. It is hard to work, and fusible with difficulty.

In China another alloy of nickel is made, the native name of which is Pakfong—white copper. It has been found on analysis to consist of 31·6 per cent. of nickel, 25·4 of zinc, 40·4 of copper, and 2·6 of iron.

Nickel is now used to some extent as a substitute for silver in the electro-plating of goods. The metal is deposited from a

solution of the sulphate or chloride, and produces a brilliant surface.

The pure metal is magnetic, and may therefore be substituted for steel in making magnets; it has the advantage over the other metal in being unaffected by the moisture of the atmosphere.

The majority of meteors exhibit a natural alloy of iron and nickel. As much as $8\frac{1}{2}$ per cent. of the latter has sometimes been found in them. Such meteoric iron, if cut and polished, will retain a bright surface with ordinary care, as nickel possesses the power of greatly retarding the rusting of iron.

CIVIL ENGINEERING.—XXII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES.

It is now necessary to introduce our readers to one of the most important of all engineering structures, whether regarded in a military or civil point of view—the bridge. The history of bridges necessarily dates from a remote period, for the indispensable character it possesses for all purposes of locomotion would justly lead us to infer that no people could ever have attained to a high degree of civilisation without some more ready means of crossing the streams by which their country would be intersected than by boats.

As may be supposed, the kind of structure employed as a bridge varies, and has varied to a very great extent. We need not travel far in order to see bridges of almost every type, from the magnificent iron roadway across the Thames at Southwark, or the substantial stone thoroughfare at London Bridge, to the miserable and dangerous wooden fabric at Putney. Indeed, scarcely a stream of any consequence exists in our own country over which in some part of its course are not to be found bridges of almost every description, from the exquisite and well-proportioned curve to the unsightly flat girder. Each, however, has its use, and our intention is to point out the principles upon which the several kinds of bridges are constructed. In our last chapter we drew attention to the method of gaining a substantial base by means of piles, and we now pass on to consider the superstructure reared thereupon.

The most natural, and at the same time the earliest, method of placing over a stream some permanent means of crossing it, is to throw over it a slab of stone or a beam of wood, resting the ends on the banks, which have been previously cut down to a uniform level. The slabs or beams may be of any number to suit the breadth of roadway required, laid side by side, with planks placed across them. There must, however, be a limit to the breadth of the stream which can be crossed by such a bridge, and a limit, moreover, to the load which such a structure could support; but it may, nevertheless, be assumed that such bridges have been common in all ages, and should the breadth of the stream be such as to preclude its being crossed by a single beam, it might easily occur to the mind of the self-taught engineer that a prop or support driven into the bed of the stream—should the depth permit it—might be made available for resting the extremities of two beams end to end upon it, and thus a stream of double the breadth might be crossed.

We purpose dividing the subject into distinct parts—*i.e.*, wooden bridges, stone or masonry bridges, iron bridges, and suspension bridges.

A wooden structure, such as we have alluded to, may assume a form of the most primitive kind, the strength of such a bridge being, of course, simply comparative with that of the breaking strain of the beam; the stronger the beam the stronger the bridge. A little thought will, however, show that a beam perfectly equal throughout as to its section will involve a waste of material, and for the following reason. If a rod or beam be subjected to strain either laterally or end-ways, the ends being supported, it will yield most in the centre, its *absolute* strength being assumed equal throughout; and if it breaks under a load or a thrust, it will break at or near the middle. Now, the obvious method of rendering a beam under these conditions of uniform *resisting* strength throughout, will be to increase its strength in that part which experiment proves will first give way—the centre. Assuming, then, that the weakest portion of a beam for resisting purposes, supported at its extremities, is the middle, it may be inferred that its strongest portions will be close to its points of support: such is the case, and hence a beam or rod, to have uniform resisting strength throughout, should be thickest in the centre, and should taper away gradually to the ends. Hence, having ascertained the requisite dimensions for the central portion, it becomes a useless waste of material to retain equal dimensions throughout.

The same principle is involved in the case of carriage springs, where the weight of the carriage rests upon the centre of the spring, the ends being supported, only that in this case the uniform resisting strength is gained by adding additional thicknesses of spring towards the centre; and this arrangement becomes the most convenient in the case of the bridge alluded to, building up the central portions as shown in Fig. 49, by bracing together extra beams where more strength is needed. In this primitive arrangement the strength of the compound beam is equal throughout for resisting purposes. Such a mass of timber is, however, both unsightly and unnecessary, for by the introduction of struts, as shown in A A′ (Fig. 50), the weakest portion of the beam is supported. The struts may rest upon stone projections made in the piers, the other ends abutting against each other. The support thus afforded at the point B is proportioned to the strength of the struts themselves, the vertical strain at B being transferred into the diagonals indicated by the arrows parallel to the struts, and received upon the projections C, D; hence the piers themselves become the recipients of the entire load resting upon the horizontal beam. The tendency of the thrust on the struts is to buckle them, and therefore a tie-beam, as shown at A in Fig. 51, may with great advantage be introduced. Thus step by step we become aware of the value of the various timbers introduced into all structures which have to support a weight in a given direction; and it is only by a careful consideration of the real direction of strain that the several supports are placed just where they will best serve the purpose intended. These forms of construction of timber bridges are very far from constituting the only kinds of such structures. The diversity to be met with is very great. Timber of sufficient length cannot always be found, and hence some arrangement of the struts to meet the difficulty must be adopted. An instance occurs at Lyons, where a bridge is thrown across the Rhone. In Fig. 52 is shown the arrangement of the timbers in this structure. Here the support is given at the intermediate points A, B, C, D, and E, and the necessity for the long strut from C to C′ is avoided.

By the adoption of a framed rib, as shown in Fig. 53, as great an amount of strength is gained as in the arrangement Fig. 52, and a lighter-looking structure results. Lattice-work girders, now so commonly met with in iron bridges, are, however, by no means confined to iron, and in America are to be found several noteworthy instances of timber lattice-work bridges spanning very wide rivers in that country.

An elegant adaptation of lattice-work, known as Long's, is much employed in America. It consists, as shown in Fig. 54, of a series of St. Andrew's crosses between vertical posts, the posts being securely bolted at their extremities into the horizontal timbers. Here the thrust lies in the direction indicated by the arrows, whilst at the same time the girder itself is possessed of great strength. The depth of the framing must be proportioned to the distance between the piers.

An important modification of the timber bridge is shown in Fig. 55, where the strength of the girder is increased by resting it, either from above or below, upon rods or chains of iron, A A′, the thrust being delivered by the vertical pieces 1, 2, 3, 4. This constitutes a form of suspension bridge, the vertical strain being transferred to the rod A A′, and the load-bearing strength of the span being proportioned to the tensile strength of the rod.

The true curve may be theoretically regarded as consisting of a polygon whose sides are infinite in number and infinitely short, arranged in the line of curve. Hence, if we regard the arch as the strongest of all forms for a bridge, the nearer we approach it the stronger will be the resulting structure. The straight line or girder bridge is as far removed from the arch as possible, and hence it has the least strength, independently of the framework or absolute and inherent strength of the thing itself. The simple struts (Fig. 50) break the straight line, and become the next step in the acquirement of strength. In Fig. 52 another side is added to the polygon, and in Fig. 53 the sides are still further increased in number, with proportionate advan-

tage. The introduction of bent timber, as shown in Fig. 56, brings us at once to the arch. Here, so long as the bent portions are kept efficiently tied, the greatest amount of strength is obtained.

A powerful combination of timbers in which curved work is introduced is obtained by the introduction of vertical as well as inclined struts, as shown in Fig. 57. The timbers which form the arch are scarfed, care being taken that no two scarfs occur between the same pair of principals. The various courses of bent timber are firmly united between each principal by bolts and nuts, *a*, *a*, *a*. A timber arch, constructed upon this arrangement, may be made of very considerable span; but in all timber bridges of large span, it is necessary to bear in mind its tendency to horizontal confine the thrust to the tie-beam itself, as in Fig. 58, where the struts are mortised into it. Such a combination forms a very strong arrangement, the entire frame being complete in itself.

The flooring or roadway of timber bridges should be protected as much as possible from the action of the weather, and from the damage arising from traffic. If covered with soil, unnecessary weight is added, and dampness, which is prejudical to the stability of the timber, is retained. For these reasons, a false floor is preferable, as it can be easily remedied without detriment to the main structure. Advantage will also be found in covering the main roadway with a sheeting of lead or copper, the expense being only in the first outlay, with a subsequent saving, consequent upon the greater durability obtained.

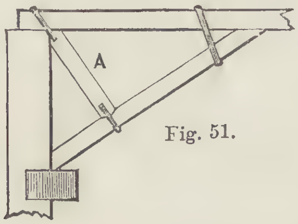


Fig. 51.

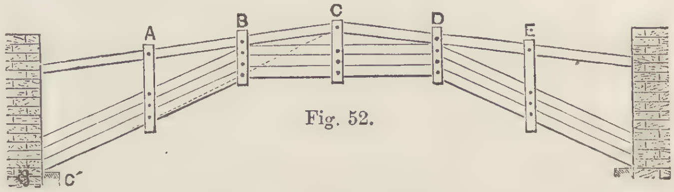


Fig. 52.

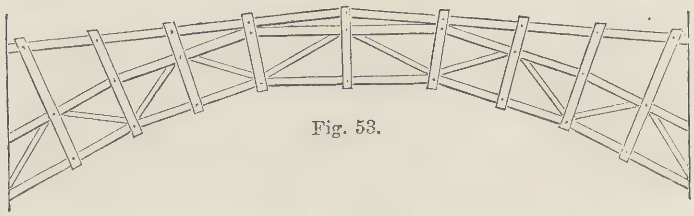


Fig. 53.

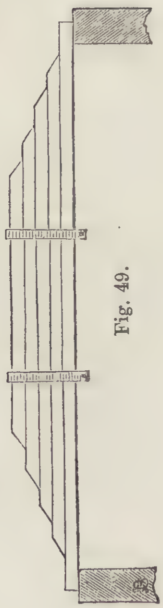


Fig. 49.

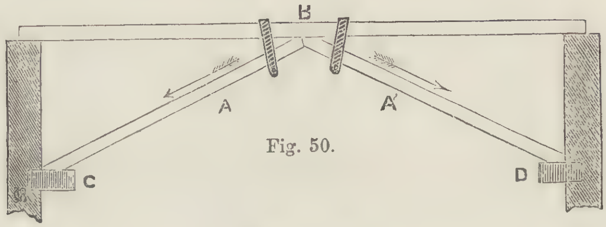


Fig. 50.

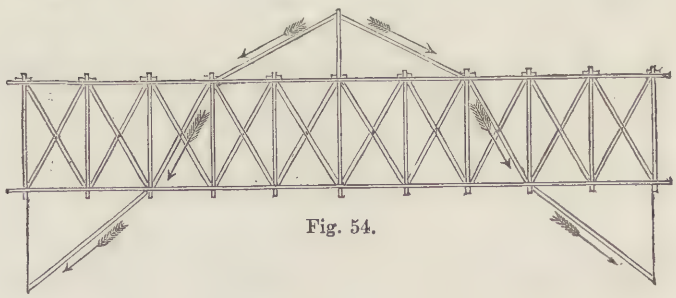


Fig. 54.

movement. This must be guarded against by every possible means. The inclined struts become of value in this respect by preventing any movement of the principals, and at the same time securing the necessary rigidity in the flooring. In all timber structures there is a greater or less risk of movement of the parts from the imperfection of the workmanship, as well as from the shrinking and warping of the timber itself; hence a settlement of the arch may be anticipated and prepared for. A formula for the lowering at the middle in bridges of fir timber has been given, derived from observation. It is $\cdot 02 \frac{f}{c}$, in which c represents the opening of the arch, and f its settlement immediately after building; it increases, however, by subsequent alteration of the timber.

In our previous examples we have described timber bridges in which the supporting timbers abut against the walls, and exercise a thrust. It is possible, however, to prevent this, and to

Timber becomes a very useful material for the construction of foot bridges. In Holland a considerable variety of such bridges occurs over the numerous canals which intersect that country. In Figs. 59 and 60 we give two instances, the first occurring over the canal of Gouda, having a span of 45 feet; the other, of the same span, over the canal at Utrecht. A valuable combination of struts is to be seen in a bridge over the Loire, of three arches, each 92 feet span. It is shown in Fig. 61. The arch is formed of a polygon, five sides of which appear between the abutments. The angles formed at the points of union of these sides meet in the centre of corresponding timbers placed over them, and the pendant binding pieces are securely braced.

We cannot omit an interesting and early instance of the application of the suspension principle to a timber bridge which was built over the Durance. This bridge had a span of 115 feet. The centre bay was held up by four radiating posts

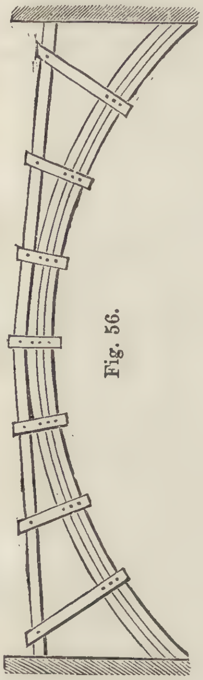


Fig. 56.

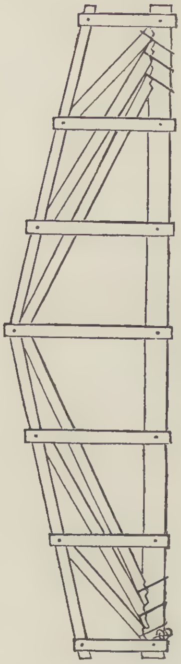


Fig. 58.

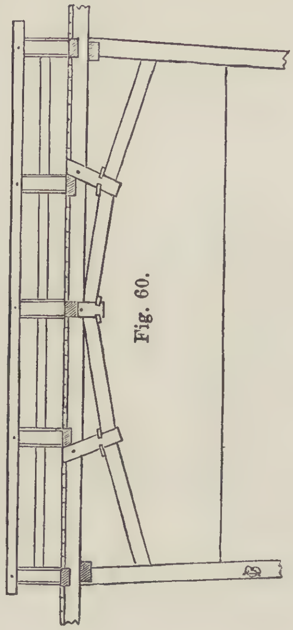


Fig. 60.

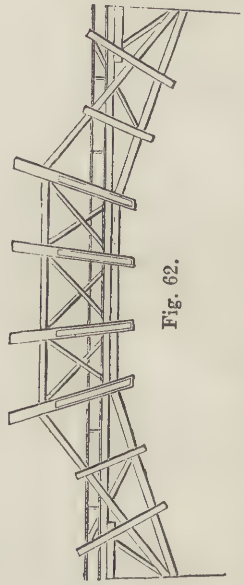


Fig. 62.

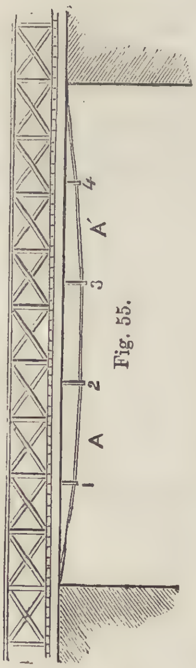


Fig. 55.

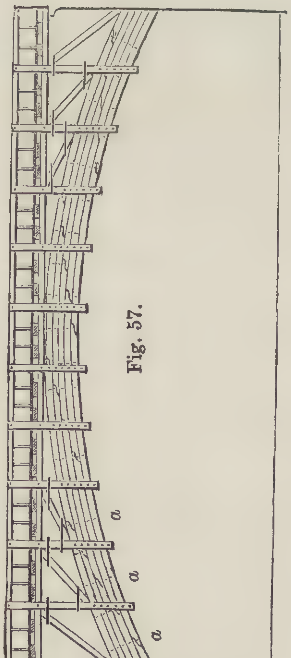


Fig. 57.

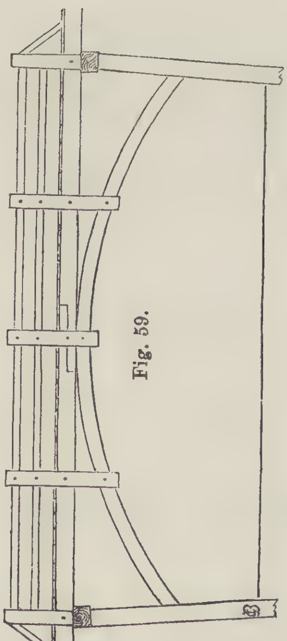


Fig. 59.

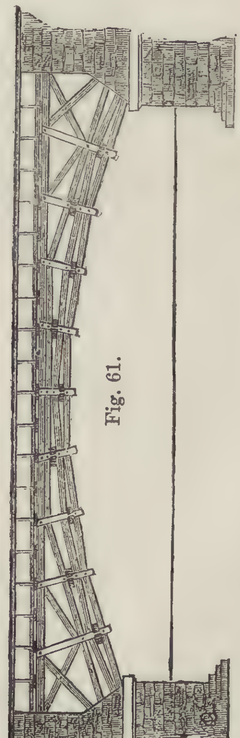


Fig. 61.

(Fig. 62), kept in their position by horizontal timbers and St. Andrew's crosses, the whole forming, as it were, a framed key-piece, supported at its extremities by inclined struts resting on the abutments, the struts bearing against both the heads and the sills of the suspension posts.

In America, where timber is readily obtainable, timber bridges are to be found in great variety, and many of them of large dimensions. A timber bridge was built in 1804 over the Delaware, at Trenton, which consists of five arches of different span, and crosses the river where its width is 1,100 feet. The roadway is suspended from the arch by vertical iron rods, placed in some cases 8 feet apart, and in some 16 feet. The joists which carry the roadway fit into stirrups at the lower end of the rods. A still larger timber bridge of the same character occurs over the Susquehanna, in Columbia. It consists of twenty-nine arches, each 200 feet span, supported on two abutments and twenty-eight stone piers.

In the instances we have given of timber bridges we have by no means exhausted the subject, for bridges constructed of this material are to be found in almost every part of the world, of an almost endless variety of type.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XL.—RENÉ DES CARTES.

BY JAMES GRANT.

The inventor of the Cartesian system, as it is called, René Des Cartes, than whom few philosophers have a higher claim to distinction, was a Frenchman, and native of Touraine, where he was born in 1596, during the reign of Henri IV., a stormy period of French history, and two years before the famous Edict of Nantes became law.

While a child, he acquired the sobriquet of "the young philosopher," from the eager curiosity he displayed to inquire into and discover the nature and causes of things. In the year 1604 he was committed to the care of a learned Jesuit, under whose tuition he made uncommon progress, and displayed a wonderful aptitude for proficiency. He soon began to discover defects in existing systems, and hoped to be the means of giving to science an aspect at once new and more pleasing.

After having spent five years in the study of polite literature and of languages, he entered upon a curriculum of morals, logic, and mathematics, according to the methods in which they were taught during the sixteenth century. With these methods he was disgusted, or rather so perplexed, that he determined to form for himself a system of rules, or canons of reasoning, in which he followed the method of the geometricians. However, after all, he was so little satisfied with his own progress and attainments, that he left college, lamenting that the fruits of eight years' close application and hard study were only the full conviction, that as yet he knew nothing with clearness and certainty.

He even threw his books aside with a resolution to pursue no other knowledge than such as he could find within himself and in the great volume of Nature. At the age of seventeen he was sent to Paris, and there the love of pleasure for a time overcame all desire of philosophical distinction. It was the Paris of Henri IV., and morality at that period was at a somewhat low ebb, for in that year the king obtained a sentence of divorce from his queen, with the public and avowed intention of marrying one of his mistresses, whom he had created Marchioness of Verneuil, but was induced, by the remonstrances of Sully, to marry Marie de Medicis.

A chance introduction to some learned men recalled the attention of René Des Cartes to mathematics, and this science he again prosecuted in solitude for two years, after which he resolved to become a soldier, and in 1615 he entered the army of the States of Holland as a volunteer. The Dutch were then engaged in a quarrel with the Elector of Brandenburg and the Duke of Nieuburg, concerning the joint possession of the duchies of Juliers and Cleves; but the prospect of a serious war passed away, and Des Cartes, while in the Dutch service, wrote a "Dissertation to prove that Brutes are Automata."

From the service of Holland he passed into that of the Duke of Bavaria, William, a strong supporter of the Jesuits; but wherever René went he conversed with learned men, and notwithstanding his coat of mail and harquebuss, appeared rather in the character of a philosopher than that of a soldier.

At last he grew weary of wandering, and, quitting the army in 1622, he returned to his native country, with no other profit, as he said, "than that he had freed himself from many prejudices, and rendered his mind more fit for the reception of truth."

In Paris he fixed his residence, when Louis XIII. had been twelve years on the throne, and then he resumed the study of mathematics, in hope of discovering the general principles of relations, measures and proportions, applicable to all subjects, by means of which truth might, with certainty, be investigated, and the limits of knowledge be extended. He turned his attention from mathematics to ethics, and attempted to raise a superstructure of morals upon the foundation of natural science, as he conceived that there could be no better means for discovering the true principles of action, than by the contemplation and study of our own nature, and the nature of the world around us; and as the result of these reflections and inquiries, he wrote a treatise upon the human passions.

Having spent some time in Italy, whither he had gone in pursuit of knowledge, he returned again to Paris, and from thence he went again to Holland with the view of founding a new system of philosophy; and there he chose retirement as the best means of forwarding the object he had in view and the plans he hoped to execute. While employing himself in the investigation of a proof from reason, independently of revelation, of the fundamental principles of religion, and publishing his "Philosophical Meditations on First Philosophy," he pursued at the same time his physical inquiries, and published a "Treatise on Meteors."

To medicine, anatomy, and chemistry he paid considerable attention; and he also wrote an astronomical treatise on the system of the heavenly bodies, which he suppressed on hearing of the vile and unjust treatment which Galileo had met with for his discussion on the same subject, as related in THE TECHNICAL EDUCATOR, page 54, Vol. II.

The Cartesian system of philosophy was first taught in the schools of Deventer, a town of Holland in the province of Over-Yssel, the native place of the philosopher Gronovius, and where Erasmus was a student; and in England it obtained so much credit that the inventor was invited by Charles I., and some of the principal nobility, to settle there, an invitation which he would probably have accepted, had not the storm of the Great Civil War prevented the king from being able to extend to the philosopher all the patronage which he had formerly offered him.

About this time Des Cartes was lured or provoked into many angry, yet learned, disputes, in the course of which, as well as by his collateral conduct, he evinced an earnest desire to be viewed as the father or founder of a sect; and thus was alleged to discover more jealousy of others, and more personal ambition, than became so great a philosopher. On the subject of logic, he wrote thus:—

"Nothing is ever to be admitted as true which is not certainly known to be so, and which cannot possibly be doubted. In proving any truth, the ideas are always to be brought forward in a certain order, beginning with things the most simple, and by regular steps advancing to those which are more complex and difficult." Concerning metaphysics, he says, that since man is under the influence of prejudice, he ought, *once* at least in his life, to doubt of everything, even whether sensible objects have a real existence, and also of the truth of mathematical axioms. The first principle of the Cartesian philosophy is this, "*I think, therefore, I am:*" this is the foundation of his metaphysics; and the structure on which his physics is built is, "*that nothing exists, but substances.*"

The latter he made of two kinds; the one that thinks, and the other that is extended, so that thought on the one hand and extension on the other make the essence of substance. Having thus fixed the essence of matter in extension, Des Cartes concluded that there is no vacuum in Nature, nor any possibility of it; but that the universe is absolutely full. By this principle mere space is quite excluded, for extension being implied in the idea of space, matter is so too.

Motion he defined to be the translation of a body from the neighbourhood of others that are in contact with it, and considered as at rest, to the neighbourhood of other bodies. By

this hypothesis he destroyed the distinction between motion that is absolute or real, and that which is relative or apparent. He maintained that the same quantity of motion is always preserved in the universe, because God must be supposed to act in the most constant and immutable manner, and hence he also deduced his three laws of motion.

"Upon these principles Des Cartes explains mechanically how the world was formed, and how the present phenomena of nature came to arise. He supposes that God created matter of an indefinite extension, which he separated into small square portions or masses full of angles; that he impressed two motions on this matter; the one by which each part revolved about its own centre; and another, by which an assemblage, or system of them, turned round a common centre. From whence arose as many different vortices or eddies, as there were different masses of matter, thus moving about common centres. . . . Now the first or most subtile element, according to the laws of motion, must occupy the centre of each system, or vortex, by reason of the smallness of its parts; and this is the matter which constitutes the sun, the fixed stars above, and the fire below. The second element, made up of spheres, forms the atmosphere, and all the matter between the earth and the fixed stars; in such sort, that the largest spheres are always next the circumference of the vortex, and the smallest next its centre. The third element, formed of the irregular particles, is matter that composes the earth and all terrestrial bodies, together with comets, spots in the sun," etc.

During the residence of Des Cartes in Holland, he went occasionally to his native country, where in 1643 he published an abstract of his system of philosophy, under the title of "Philosophical Specimens;" and on one of these visits he was promised an annual pension of 3,000 livres, which he never received.

Christina, the Queen of Sweden, invited him to visit Stockholm. That learned princess had read with avowed pleasure his treatise "On the Passions," and was earnestly desirous of being instructed by him in the principles of his philosophy. In obedience to her invitation, he arrived at the Swedish capital in 1649, at a time when refinement and literature had made but little progress among the warlike Swedes, whose martial spirit was then at its height, after the long Thirty Years' War; but he received a warm and friendly welcome from the young queen, who urged him to settle in her kingdom, and assist her in the formation of an academy of sciences.

Des Cartes had only been four months in that northern climate, when, in a severe season, during one of his visits of instruction to the queen, he caught a cold, that brought on an inflammation of the lungs, which put a period to his existence in 1650. His remains were interred in the common cemetery set apart for all foreigners near Stockholm, and a long eulogium was carved upon his tomb; but in 1666 his bones were exhumed and transported to France, and solemnly deposited with all the circumstances of pomp in the Church of St. Geneviève at Paris—not the present Pantheon in the Rue St. Jacques, but the older fane in which the saint herself was deposited in the sixth century, and which was only demolished in the beginning of the present century. His remains, however, probably lie undisturbed in the subterranean church.

Of René Des Cartes many eulogia have been published by persons capable of appreciating his worth.

In his "Opuscula" Dr. Barrow observes that Des Cartes was doubtless a very ingenious man, a real philosopher, and one who seems to have brought those assistances to that part of philosophy relating to matter and motion, which perhaps no one had done before—namely, a great skill in mathematics; a mind habituated by nature and custom to profound meditation; a judgment exempt from all errors and prejudices; an entire disengagement by his own choice from the perusal of useless books, an incomparable acuteness of wit, and perspicuous power of expression. Dr. Halley, in a paper on Optics, says he was the first who in modern times discovered the laws of refraction, and brought dioptrics to a science; however, Dr. James Keill, the celebrated Scottish astronomer and mathematician, took a different view of him, and asserts that Des Cartes was so far from applying geometry and observation to natural philosophy, that his whole system is one continued blunder, on account of his negligence in that particular point, which he could easily prove by showing that his theory of vortices, upon which his system is founded, is absolutely false.

"Recueil de quelques Pièces curieuses concernant la Philosophie de M. Descartes," appeared in 12mo at Amsterdam in 1694; and a complete edition of all his works, in eleven volumes 8vo, was published at Paris by Victor Cousin in 1824-6.

OPTICAL INSTRUMENTS.—XXII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN.

Its History.—The invention of the magic lantern has been ascribed by some authors to Friar Bacon, on account of an old Oxford legend which relates, that he had been seen walking in the air between two steeples, "which was thought to be done by glasses when he walked upon the ground:" this would carry the discovery of its principles back to about the year 1260. From a graphic description given by the celebrated Florentine engraver, Benvenuto Cellini, of a necromantic ceremony performed by a Sicilian priest at the Colosseum, which lasted above an hour and a half, whereat legions of devils seemed to fill that vast amphitheatre, others have referred its discovery to the early part of the sixteenth century, as Cellini speaks of trying to quell the intense fear and horror of his companions by telling them "that all these demons are under us, and what ye see is but smoke and shadow;" thus indicating his personal knowledge of an optical origin for such frightful visions. A declaration made by a boy who accompanied Cellini on the occasion is further suggestive of the optical arrangement employed, for he states, "As we were going home to our houses in the Quarter Banchi, *two of the demons whom we had seen at the Amphitheatre went on before us*, leaping and skipping, *sometimes running upon the roofs of the houses and sometimes upon the ground!*" Cellini, it may be mentioned, died in 1570. It was not till the seventeenth century, however, that a definite account of the construction of the "Magic Lantern" was given to the world, in a Latin work entitled "Ars Magna Lucis et Umbræ," or "The Great Art of Light and Shadow," by Athanasius Kircher, a Jesuit living at Rome, who was born in 1601.

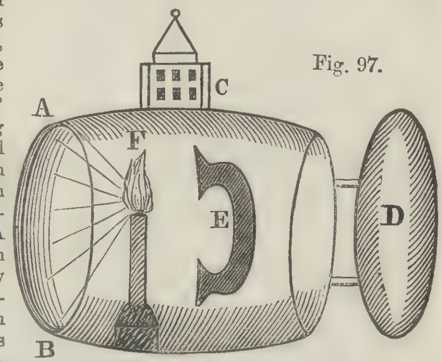


Fig. 97.

Kircher ascribes his knowledge of this instrument to a mathematician named Thomas Walgenstenius, a Dane, who constructed magic lanterns and sold them as rare curiosities to the Italian princes and other wealthy and learned people. Such lanterns appear to have been cumbrous and rudely made. In the first edition of Kircher's "Ars Magna Lucis et Umbræ," published at Rome in 1646 by Ludovici Grignani, a rude engraving (copied in Fig. 97) represents a barrel-shaped lantern, one end being filled up with a concave reflector, A B, which projected the rays of a wax taper, F, through a double-convex lens, D, the slide being inserted in the opening between the front of the lantern and the lens, and the smoke carried off by a chimney, C. This arrangement was portable, and could be carried by handles, E, fixed to the side. Its object, it is stated, was to show an inscription on a wall at a distance from the lantern. In the second edition of this work, published at Amsterdam in 1671, Kircher gives the result of his knowledge acquired from Walgenstenius, his descriptions being illustrated by two beautifully executed engravings, one of which is copied in Fig. 98. This represents a large square wooden box, or rather a chamber, some six feet square, with a door on one side, fitted with a tube, C, that carried the painting and lens, or lenses; the source of light was an oil lamp, L, with a polished brass reflector placed behind the flame. This lamp was fixed beneath a chimney fitted to the top of the box to carry off the smoke, and from Kircher's representation the lamp appears to have

been a very smoky one, devoid of anything in the shape of a lamp-glass or chimney. Kircher's slides consisted of rude figures of spectres, skeletons, demons, etc., painted on glass, within circles, three or four subjects being painted on one slide. This chamber was separated from the room in which the spectral images were shown on a smooth whitened wall by a partition, through a hole in which the rays from the lantern passed. Now it will be observed, that though a lens corresponding to the modern condenser is represented at C, no indication is given in this drawing (or in the fellow-representation) of any power or magnifying lens. It is quite obvious that the light collected by C passing through the slide could only give such a shadowy picture as light passing through a stained-glass window projects. Did he form his image by means of a very small hole in the partition? As this method with such a poor light would give anything but a satisfactory result, it is more probable that a magnifying lens was fixed in the hole in the partition to attain the amount of definition he indicates. His reticence on this important point is remarkable, when he has in other respects given such elaborate illustrations, and his work shows that he possessed a large amount of optical knowledge, while he also exhibited in numerous other works a vast amount of information on scientific, antiquarian, linguistic, and mathematical subjects. Kircher for a long period gave exhibitions of this optical novelty in his room at the Jesuits' College at Rome, which were nightly thronged by the noble and wealthy inhabitants of that ancient city. Most authors on optical subjects seem to credit Kircher as the inventor of the magic lantern; but it is probable that that instrument took form by gradual improvement till the period at which Kircher published his description of its arrangement in his "Ars Magna Lucis et Umbræ."

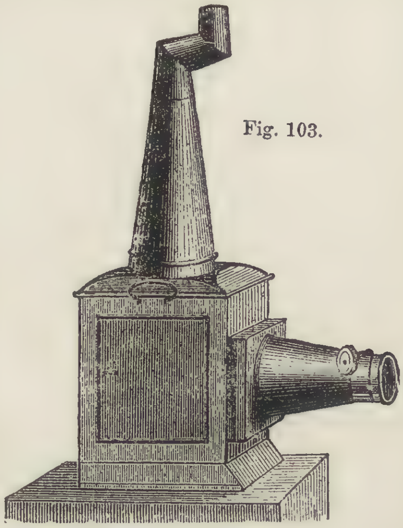
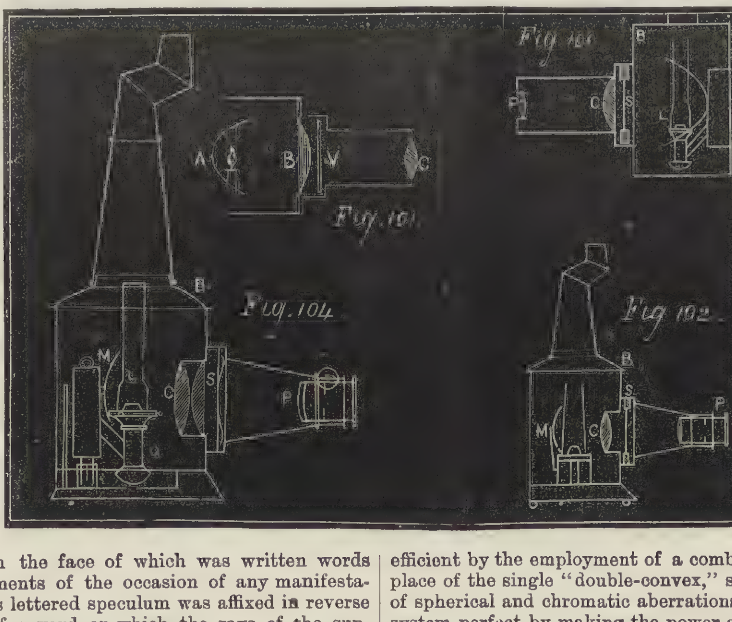


Fig. 103.

As specula and lenses were known to the ancient Egyptians, it is not improbable the learned priests of the temples availed themselves of such optical aids to minister to their acquiring power over the minds of the people and even the mighty of the land. We can imagine the priests availing themselves of the intense illuminating power of a tropical sun, in some such arrangement as that described by Schottus and shown in Fig. 99. In this O represents a metallic speculum, on the face of which was written words suited for the requirements of the occasion of any manifestation in a temple. This lettered speculum was affixed in reverse position to the wall of a yard on which the rays of the sun, S, could fall, such speculum being opposite to and in focus with a lens, L, let into the wall of a temple facing the altar at which the manifestation was to appear on a screen of drapery, D, placed in the conjugate focus of the lens L, and consequently in the position where an image, I, of the object, or words on the speculum O, would be projected. We can imagine as the next step towards an improvement on this crude arrangement that the speculum would be replaced with an opaque sheet of metal, etc., out of which the letters or object could be cut, as in a stencil plate, and the sunlight reflected through it; next that the orifices in the plate should be covered over with transparent coloured papers; then that the light of the sun would be replaced with an artificial source of light, such as that of a lamp fed with fat, to which would next be added a concave mirror, the prototype of the lantern condenser—for few would imagine, unless they had tried it, how bright a picture can be produced by concentrating the light on the slide by means of a concave reflector only—an important advance, as the necromantic manifestations to which the lantern lent its aid could then be called into play at any time required, more especially "at the witching hour of night." Next, the stencil plate would give place to rough paintings on glass, and we should find the arrangement much as Kircher described it in the seventeenth century, shown in Fig. 97, and possibly such as Cellini's friend, the Sicilian priest, employed at the Coliseum some fifty years before Kircher's *séances*, for from Cellini's narrative it may be surmised that the lantern used on that occasion was portable, and consequently more compact than Kircher's lantern, as shown in Fig. 98.



Not much advance could be expected from that date till the introduction in 1789 of the circular wicked burner, with central air-way, oxygenating cone and glass chimney, by Aimé Argand, the inventor of the "Argand lamp." To the Argand burner was added the parabolic reflector, the most perfect collector of light, when properly constructed. An additional means of concentrating the light was gained by the introduction of a glass "condenser;" this at first was placed between the picture, S, and magnifying lens or "power," P, and in focus with the flame of the lamp, L, as shown at C in Fig. 100; afterwards the stage for the slides was placed between the condenser and power, and close up to the former, as shown at B in Fig. 101, which may be regarded as the type of modern lantern construction. The condenser has been used in the form of the "bulls'-eye," the "double-convex" (the best form for pictures not over $2\frac{1}{2}$ inches in diameter); the "double condenser," wherein two lenses are used in place of a single lens; and the "triple condenser," composed of three lenses. The magnifying part has been rendered more efficient by the employment of a combination of two lenses in place of the single "double-convex," so as to reduce the amount of spherical and chromatic aberrations, and render the optical system perfect by making the power achromatic in conjunction with condensers of short focus, and of such curves as yield a flat and colourless field. The sources of light have been improved on by the adoption of the oxy-calcium, oxy-hydrogen, magnesium and electric light, to suit the requirements of the exhibitor, and the entire instrument has been rendered perfect by carefully-devised arrangements for making it compact, portable, and so ready to the hand of the exhibitor, that all its parts and accessories may, in the course of a few minutes, be unpacked,

and placed in position for work in any room, and be packed and removed as quickly. Further, the attention that has of late years been given to the improvement of the magic lantern has raised it from the position of a mere nursery toy to that of an important physical instrument of the greatest educational value, especially when employed in conjunction with photographic slides, whether produced from natural scenes and objects, or artistic drawings of subjects not attainable direct from nature, according to the system previously advocated at pages 244, 275, Vol. II., of THE TECHNICAL EDUCATOR.

The Choice of a Lantern.—Magic lanterns are offered to the public in a variety of sizes and qualities, ranging in price from five shillings to fifty pounds, so that the uninitiated often feel a difficulty in making selection of a useful instrument; but the range, practically, is very limited. In the first place, the purpose for which it is required must be determined; in the next place, the amount to be expended.

If a toy is required for the nursery, "a child's lantern," with twelve long slides in a box, can be purchased for 7s. 6d. Such a lantern would be fitted with a single condenser of $1\frac{1}{2}$ inches diameter, and $2\frac{1}{2}$ inches focus, with a double-convex power of $2\frac{1}{2}$ inches focal length, which would give a sufficiently bright disc of 3 feet diameter at 6 feet distance from the screen. "The Guinea Lantern," with a box of a dozen long sliders, is well suited for a Christmas box; this gives a 4-foot disc at 6 feet from the screen, with a condenser of $2\frac{1}{2}$ inches diameter and $2\frac{1}{2}$ focus, and a double-convex power of 3 inches focus. If a useful instrument is desired, one that can be added to from

Fig. 99.—SUPPOSED USE OF THE PRINCIPLES OF THE MAGIC LANTERN BY THE EGYPTIANS.

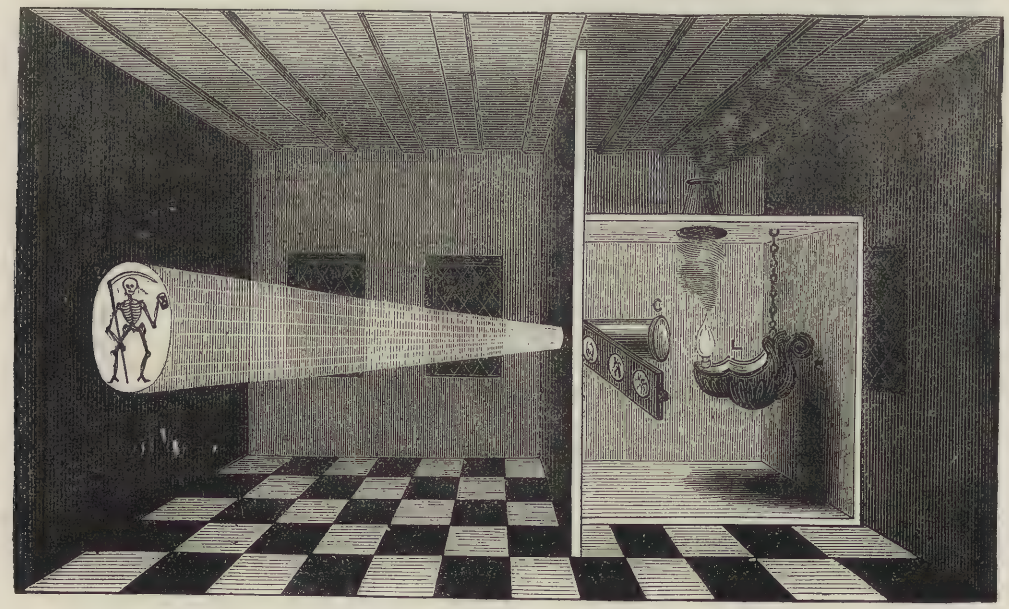


Fig. 98.—THE MAGIC LANTERN AS EXHIBITED BY KIRCHER.

time to time, and be made a source of varied amusement, wherein action can be given to the figures and mechanical and chromatropic effects produced, then the cheapest lantern that can be purchased is "The School-boy's Magic Lantern," for showing 2-inch pictures, and the smallest size of comic slip slides, chromatropes, etc., which may be bought for about a guinea and a half without slides. This lantern has a condensing lens of $3\frac{1}{2}$ inches diameter and 3 inches focus, with a plano-convex power of $3\frac{1}{2}$ inches focal length, which yields a disc of 6 feet diameter when placed 10 feet from the screen, the lamp in this case being of Argand construction, as shown in Fig. 102. As, however, a disc of glass only 2 inches in diameter does not present much scope for producing any artistic effect, it is undoubtedly cheaper in the long run, where cost is not a matter of grave consideration, to purchase a thoroughly good instrument in the first instance, wherewith to show slides of 3 inches diameter, which, since the application of photography to the production of magic-lantern slides, may be regarded as *the standard size* for lantern views, for those of greater diameter only involve a more cumbrous apparatus, without a compensating result, and further, a considerable additional expense, as slides of greater diameter than 3 inches are seldom kept in stock by opticians. Slides over 3 inches have therefore to be produced to special order, which consequently involves a delay in getting supplied, unless a selection of subjects be given many months before such slides are required for the winter season, on account of really artistic slide-painters being *very* limited in number, and those who bear the palm in this profession always having their time fully occupied. Artistically painted slides of 3 inches diameter demand an arrangement of superior construction for their exhibition, wherein the source of light should at least be a fountain Argand, such as is shown in Fig. 86, page 324, and Figs. 91, 92, page 365, Vol. III. of THE TECHNICAL EDUCATOR; the condensers composed of two lenses of $3\frac{1}{2}$ inches diameter (as the condenser should always be at least half an inch larger than the greatest diameter of the picture to be shown by it), and 3 inches combined focus, and the power formed of a combination of two meniscus lenses of 4 inches combined focus, which gives a flat field with tolerable definition in the image, though not quite free from chromatic fringes. Such an arrangement is embodied in "The Family Phantasmagoria Lantern," which gives a 9-foot disc at 9 feet from the screen, which instrument is the stock article of the shops, and is purchasable for about three guineas. As this may be regarded as the typical arrangement for ordinary use, I have shown it in perspective in Fig. 103, and in section in Fig. 104. As will be seen hereafter, the term "phantasmagoria" is a misnomer, that term being only properly applied to a lantern of more complicated mechanical construction for the purpose of making the image rapidly increase or diminish in size, and seem to approach or recede from the spectators.

Before concluding the present article, I may here state that the four lanterns previously described are really very cheap, as they are made wholesale in very large quantities, by a few manufacturers who supply all the London and provincial shops of sellers of optical goods, whether they be opticians pure and simple, or those who combine the sale of optical wares with pharmaceutical preparations, tooth-brushes, bears' grease, perfumery, cutlery, watches, jewellery, or toys, whose optical knowledge is of as visionary a character as the images produced by the magic lanterns they dispose of in the same spirit as they would Dutch cheeses, or the razors made famous in Peter Pindar's poems. Beyond this point the magic lantern may be considered in the light of an educational and physical instrument, for showing with the greatest perfection geographical, historical, and scientific diagrams, or optical, acoustic, and thermotic demonstrations in the lecture-room. The selection of an educational lantern depends upon the exact purpose for which it is required, and its cost upon the amount of attention given to its construction, and details of arrangement to render it perfect for a demonstrator's requirements. As the demand for such instruments can only be of a limited nature, they are of necessity more costly than those previously described. The various arrangements can best be described under "systems" of apparatus and appliances, as "The School System," "The Photographer's System," "The Demonstrating System," "The Dioramic System," after first entering into the principles of lantern construction.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. GALLETLY, Curator, Industrial Museum, Edinburgh.

III.—HISTORY OF WOOL AND WOOLLEN MANUFACTURES FROM THE FIRST TO THE SEVENTEENTH CENTURY.

NOT much is known concerning the extent to which woollen fabrics were made during the early centuries of the Christian era. In Greece, Italy, Syria, and other countries on the Mediterranean where a high degree of skill in many arts had been long acquired, the textile industries appear to have been in an advanced state. Constantinople, whither the Greeks had carried their handicrafts in the fourth century, was especially famous for its woollens. Claudian, writing at this time, mentions clothing made of beavers' skins, which Beckmann thinks must have been spun and wove, as attempts had been previously made so to manufacture the fur of the hare. Another fabric, made with the warp of beavers' fur, and the woof of goats' hair, is noticed by Isidorus, who lived in the early part of the seventh century. At a later time the Emperor Nicephorus II. wore an upper garment of this cloth at his coronation. During the Middle Ages, whatever perfection had been achieved in the arts before the fall of Rome, was preserved chiefly at Constantinople, then the capital of the Byzantine empire; and from thence workmen skilled in weaving and other industries found their way to Italy at the time of the revival of learning and the arts. Thus it was that in the thirteenth century woollen manufactories were established at Florence, Rimini, and Perugia. These appear to have rapidly extended in number, and enjoyed considerable prosperity; but after mentioning the fact that mohair fabrics were made at Perugia as early as the fourteenth century, we proceed to trace the history of woollen textiles in those northern nations where such manufactures took deeper root.

There is evidence, which appears to be all but conclusive, that in pre-historic times the inhabitants of Great Britain practised the art of weaving, and no doubt wool must have been the material used. Primitive tools of bone, resembling metal ones still in use in India, instead of a "reed" for weaving some fabrics, have, at all events, been frequently found in Picts' houses. But the first recorded notice of the production of cloth on any considerable scale on British soil, relates to the establishment of a woollen manufactory at Winchester, during the time of the Roman occupation. It is supposed that from this factory the Roman army was supplied with clothing; at any rate it was not long before it or other British factories furnished some of the finest and most costly robes worn in Rome itself during the most luxurious era of the empire. There is little doubt that the wool employed for these fabrics, and described by one Roman writer as producing yarn so fine "that it is in a manner comparable to the spider's web," was obtained from native sheep. It is supposed that owing to the disturbed state of the country for several centuries during the time of and after the Roman occupation, the manufacture in Britain declined, although at Winchester it did not cease to exist. Nothing is known as to what change it produced in the clothing of the natives, but from the few and scanty references to the subject among our early writers we may conclude that, even in these times, the preparation of woollen yarn had become a favourite domestic occupation among them, and that the value both of the woven fabric and the material it was made of, as a source of national prosperity, was beginning to be understood.

In the year 712 the sheep is expressly mentioned for the first time in British annals, but only to refer to its price, which was one shilling of Saxon money until fourteen nights after Easter. Towards the close of the ninth century, the mother of Alfred the Great is described as being skilled in the spinning of wool; and referring to Edward the Elder, Alfred's successor on the throne, Fabian's Chronicle says that, being anxious his children should receive a proper education, "he sette his sons to scole and his doughters to woll werke." It appears, too, that Edward's first wife, Egwina, was called a shepherd's daughter, and this is explained by the fact that in the court language of those days all non-military men, of whatever rank, were supposed to be engaged in the rearing of sheep, and called shepherds. The term "spinster," by which in Great Britain all unmarried women are designated, and the origin of which cannot be traced, proves that in early times spinning must have been the common employment of females.

About the middle of the tenth century the afterwards famous

woollen trade of Flanders took its rise; and to the artisans of that country England is indebted for much of that technical instruction which so greatly aided her in laying the foundations of her vast woollen industries. In the time of William the Conqueror, a number of those skilled Flemish workmen, being forced from their territory by an encroachment of the sea, came to England, where they made fine woollens. At first they were established about Carlisle, but afterwards Henry I., finding they did not agree with his other subjects, removed them to a district which now forms part of Pembrokeshire. For a long time after this there appears to have been a large commerce in wool and woollen goods between England and the Netherlands, the latter country maintaining its pre-eminence in the manufacture of cloth, and the former its reputation for the quality and quantity of its wool. In the beginning of the fourteenth century the woollen manufactures of the Netherlands were in such a prosperous state that in the city of Louvain alone there were no less than 4,000 master weavers and woollen drapers, and above 150,000 mechanics. The quantity of wool consumed must have been very large, and it was chiefly imported from England and Spain. At this time the state of the woollen trade in England had become very depressed, on account of the wars and troubles of several successive reigns; but shortly afterwards Edward III., who did a great deal to revive it, ascended the throne. At the beginning of his reign a Flemish cloth-worker, named John Kemp, settled at Kendal, where it is said, his name still appears. The cloth called "Kendal-green" afterwards became celebrated, and is mentioned by Shakespeare. By invitations and promises Edward persuaded seventy families of Walloons to come to England, who finally settled in Yorkshire, Gloucester, and the western counties, imparting by their skill new vitality to the cloth trade of their adopted country. A greater number of Walloons subsequently came to England from the Low Countries on account of the Duke of Alva's religious proscriptions in Queen Elizabeth's time.

We may here remark that some of the northern nations of Europe—notably Denmark, Norway, and Sweden—whose whole riches had previously consisted of furs, appear to have become very slowly accustomed to the use of woollen and other woven fabrics, and that chiefly through their piratical expeditions. Even as late as the twelfth century they plainly looked upon such textiles as objects of extravagant luxury; because we find that at that time the principal men at the Danish court were clothed in sheepskin, and that the Duke Canute excited the envy of the courtiers by wearing a red cloth dress.

British wool began to be exported about the close of the twelfth century, and after Henry III. permitted the importation of foreign woollen cloth, the export trade in wool remained for centuries the most lucrative which the country possessed. About the middle of the thirteenth century, wool-staplers, or persons who arrange the wool of a fleece into different qualities, are mentioned for the first time; and in 1275 we incidentally get a glimpse of the probable quantities of British wool sent abroad. All commerce between England and Flanders having ceased through a misunderstanding between the two countries, Edward I., on account of his exhausted treasury, allowed some Florentine merchants to export 1,068 sacs (281,952 lbs.) of wool, upon which they paid 10s. per sac of duty—that sum being equal to about £7 10s. in our day. This also shows the heavy restrictions then existing on commerce, which before long became oppressive, as Edward soon afterwards doubled the duty, and in 1286 increased it to 40s. per sac. The three years' famine which followed the dreadful epidemic of 1315 caused sumptuary laws to be passed for the regulation of the price of food. From these it appears that no one could demand more than 20d. for a fat sheep, and if shorn 14d., thus giving the value of the fleece as 6d., or 7s. 6d. of the present money.

It is worth noticing here that Edward III. seems to have been, more than any other contemporary sovereign, alive to the benefits accruing to a nation from foreign commerce. He always found, when his coffers were empty, that a tax on wool was the easiest way of raising money, and on one occasion he sent a large quantity of wool to Cologne to redeem Queen Philippa's crown, which had been pawned for £2,500. As showing what such a tax then yielded, it may be stated that in 1354, when the exports of wool had reached the large quantity of 8,356,864 lbs., the duty on it amounted to £277,606 2s. 9d., an enormous sum, if the difference in the value of money between then and now be considered. About this time the first mention of exported woollen cloths and also of worsted goods occurs. The difference between these two kinds of fabrics will be afterwards explained; but we may here notice the fact that the spinning of worsted yarn had now made considerable progress at Norwich, near which, at Worstead, this peculiar kind of woollen yarn was first made. Leeds, the present centre of our woollen industry, is mentioned for the first time in connection with this manufacture during the reign of Edward III. The notice occurs in a record in the Tower of London, and refers to fulling mills in the possession of a Thomas Burgers, which were rented at 33s. 4d. per annum.

At the close of the fourteenth century the superiority of Spanish wool over the English for broad cloths began to be understood, and afterwards, accordingly, the price of British wool progressively declined; although the *long wools* of the Romney Marsh, the Lincoln, and the Leicester breeds of sheep, continued to be superior to those of foreign growth. In 1470 the price of Spanish wool appears in a claim for damages on account of a quantity seized by an English privateer. It is there put down at 6d. per lb., while the best English wool at that time would hardly bring 2d. per lb.

By the absurd enactments of Henry VII., and the religious dissensions during the time of Henry VIII., the commercial interests of the country greatly suffered, so that during both reigns the wool trade was in a declining state. Yet in the reign of Henry VIII. there were some manufacturers celebrated for their wealth, and among them John Winchcombe, popularly known as Jack of Newbury, who kept 100 looms at constant work, and was able to send sixty soldiers to Flodden Field equipped at his own expense. It would seem that Winchcombe's kerseys were highly esteemed abroad, since in a letter addressed in 1549, by the English envoy at Antwerp, to Lord Protector Somerset, he says, in reference to the payment of a large debt to the Antwerp money-lenders, "it shall be best to have hither 1,000 of Winchcombe's kerseys." In this reign we find Leeds described by a writer named Leland, who says, "The town standeth most by clothing." We must not omit to state that in 1530 the spinning-wheel was invented by Jurgen of Brunswick. It would doubtless be more correct to say that at this date he introduced it into Europe, as it had existed from immemorial time in Eastern countries. Its introduction, however, did great service to the woollen manufactures of England.

Soon after the accession of Elizabeth, under whose wise and firm rule the manufactures of the country were singularly prosperous, the persecutions in the Netherlands by the Duke of Alva, emissary of Philip of Spain, drove about 5,000 refugees to England, who settled in Canterbury, Maidstone, Norwich, Colchester, and other towns. Many of these were the most experienced and ingenious manufacturers of woollen and silk textiles of their day. By their superior machinery and manipulative skill, especially in certain kinds of light fabrics, they contributed so much to extend the manufactures of this country, that in the year 1582 the exports of British cloth were nearly double what they had ever been before. In 1600 the East India Company was established, during whose *régime* a great trade grew up, in which the woollen manufactures had a not inconsiderable share.

In the reign of James I. the art of dyeing—well known to the English manufacturer four hundred years before—had become utterly lost. The white cloths made in England were accordingly sent to Holland to be dyed and dressed—a state of matters which was not only humiliating, but was also attended with heavy loss to this country. Sir Walter Raleigh states that the profits made by the Dutch on this branch of the woollen manufacture amounted to £400,000 per annum. Strenuous efforts were therefore made to recover the lost art, and in 1667 these were at length successful. In that year a dyer, named Bremer, came from the Netherlands with his workmen, and being well treated by the English government, he made the art of dyeing so well known in England, that our woollen manufacturers were soon, in that respect, independent of the Continent.

The woollen trade was in a depressed condition under the Stuarts, chiefly on account of vexatious restrictions and prohibitions, but partly also because the manufacture had now made great progress in other European States. Nor on account of various distractions were matters much better during the Commonwealth. In consequence of the revocation of the Edict

of Nantes by Louis XIV. in 1685, about 50,000 French Protestants took refuge in England. Many of these Frenchmen were highly skilled in some branches of the woollen and felt manufactures, previously but little known in England, so that like the Flemish refugees who came over a full century before them, these foreign workmen did a lasting service to British industry. Just after the revolution of 1688 the earliest perfectly reliable accounts of the woollen trade occur. Yorkshire then begins to figure as a cloth-making county; the first suggestion of a power-loom had recently been made, and the records of the Patent Office had then begun to give all manner of details about new machines, processes, and fabrics.

INDIAN RUBBER.—V.

BY GEORGE GLADSTONE, F.C.S.

PROPERTIES OF VULCANISED CAOUTCHOUC—HOW USED—PRINCIPAL APPLICATIONS.

The special characteristics of the vulcanised as compared with the natural caoutchouc are as follow:—

1. *Influence of Temperature.*—The original article always becomes hard and loses its elasticity at about the freezing-point of water, so that it is inapplicable for many purposes where great cold is required, and is useless in such climates as those of Sweden and Northern Russia during the winter months. The frozen article recovers its elasticity on the application of heat, just as the threads already described, which have been stretched when hot and then allowed to cool, only regain their contractile power on being again warmed. No amount of cold appears to have any effect whatever upon the vulcanised rubber; neither does a thread of it, which has been stretched to the utmost, remain thus extended under any circumstances, but will always return to its original length on the tensile force being withdrawn. Turning to higher temperatures, while the native article becomes uncomfortably sticky in the heat of tropical climates, commences to melt at 248°, and if heated up to 398° will no longer return to the solid state on cooling, the vulcanised is in no degree affected by exposure to any temperature short of 300°, but becomes harder on the heat being still further raised.

2. *Adhesiveness.*—This, which in the original article is often a source of inconvenience, while at other times it is of very great advantage, is entirely lost under the process of vulcanisation. This circumstance frequently necessitates a considerable change in the process of manufacture.

3. *Impermeability to Water, etc.* — Both descriptions of material seem to be equally efficient in this respect.

4. *Insolubility in Acids, Alkalis, etc.*—In this particular the vulcanised far exceeds the ordinary rubber. It is true that any excess of sulphur which may exist in the converted article may be removed by those chemical reagents which will act upon the sulphur itself; but this is an advantage rather than otherwise, as such sulphur would cause an unpleasant odour, and in process of time be liable to effloresce upon the surface of the rubber, a probability which the manufacturer has always to guard against; but beyond this the greater part of the sulphur which it was found necessary to use in order to produce vulcanisation may be subsequently removed by chemical means without destroying the effect, so that not more than 1, or at most, 2 per cent. may remain. So completely, indeed, may the sulphur be removed, that it has been doubted whether this ingredient enters into chemical combination with the Indian rubber at all, and whether the vulcanised article should not be regarded as merely an allotropic condition of the other. Except in this respect the vulcanised product is equally insoluble in all the menstrua in which the original article is; but beyond this it is less soluble in the liquid hydrocarbons and other solvents of the native rubber; and, which is a matter of no small practical importance, the non-drying oils, grease, etc., do not affect it at all.

5. *Pliancy.*—In this respect the vulcanised article is undoubtedly superior, for while it loses nothing at the ordinary temperatures, it will be seen from what is said under the first head greatly to excel the raw product both at high and low temperatures.

6. *Elasticity.*—We now come to the most valuable characteristic of the native rubber, and it is something to say that this is not injured by vulcanisation. We may go further, and add that it is greatly improved by this process, provided that the temperature at which it is conducted be not too high. Its elastic power is a matter of such importance as to call for considerable detail. The extent to which it may be stretched, and the readiness with which it returns to its original dimensions on being let go, may be easily illustrated by a reference to the elastic bands which are now in such extensive use that almost every individual in the kingdom, whether high or low, must be familiar with them. Had the discovery been applicable to no other purpose than this, it would even then have been one of no trifling importance. The converse, its power of resisting pressure, and of returning to its former thickness on the compressive force being withdrawn, has been very thoroughly tested in the following manner, and with the result stated:—A block of the vulcanised article, of the kind used for the manufacture of railway-carriage springs, measuring 6 inches outside diameter, and 6 inches depth, with a hole through the centre of 1 inch diameter, was taken and put under a press. A pressure of $\frac{1}{2}$ ton reduced it to a depth of $5\frac{1}{16}$ inches; 1 ton to $5\frac{1}{16}$ inches; $1\frac{1}{2}$ tons to $4\frac{9}{16}$ inches; 2 tons to $4\frac{3}{16}$ inches; $2\frac{1}{2}$ tons to $3\frac{13}{16}$ inches; 3 tons to $3\frac{4}{16}$ inches; $3\frac{1}{2}$ tons to $3\frac{1}{12}$ inches; 4 tons to 3 inches. The block was left under pressure for forty-eight hours, and in each case returned to its original dimensions after a short period when the pressure was removed.

Such being the leading characteristics of the vulcanised caoutchouc, it will only remain to describe those processes of manufacture which differ from those of the native article, and to refer to some of the applications for which it is suited.

In making the vulcanised article a great variety of expedients have been adopted for producing further modifications, and all sorts of articles, such as lead, antimony, chalk, magnesia, phosphorus, etc., in some form or another, have been compounded with it. Some of these considerably add to the weight of the product, and some, perhaps, serve no other useful purpose beyond this, that they generally increase its solidity, though they diminish its elasticity. It may, therefore, be taken that the compound of caoutchouc with sulphur only, one cubic foot of which will weigh about 60 pounds, is the best article, and that any samples which exceed that weight are of inferior quality, though for certain special purposes they may be desirable. The compounds are so various that some samples will weigh more than half as much again as the figure above given; but the buyer of such should understand that part of the price he is paying is for so much mineral.

It must not be understood, however, that all these substances are deleterious. Magnesia imparts a softness to the surface which is generally agreeable; the sulphide of antimony is also used to make what is known as red rubber, which possesses good general qualities, especially as to its elasticity, while it is less liable to that measure of decomposition which more or less affects all Indian rubber and its compounds after years of exposure to the air, rendering it brittle and no longer elastic.

The process of making this kind of rubber is as follows:—The crude sulphide of antimony is finely pounded and then boiled in water with one of the alkaline carbonates, by which, and the addition of a slight excess of hydrochloric acid, it is converted into kermes mineral, the orange-coloured double sulphide. This is worked up with the Indian rubber in the masticator, and subjected to a temperature of about 280°.

In consequence of the loss of a very convenient property of the original substance—viz., its adhesiveness—the vulcanised goods are very frequently made of the common rubber, and then submitted to the action of the sulphur. Another plan which may also be adopted with advantage is to work in the sulphur along with any other ingredients that may be desired, such as the silicate of magnesia, or any colouring matter, during the process of mastication, taking care to keep the temperature sufficiently low to avoid vulcanisation; and then, after the articles intended have been manufactured from this compound, to submit them to a temperature of 280° or upwards.

The time required for effecting the change varies in proportion to the thickness of the mass. Thus, in the previous extract from Mr. Hancock's patent (Article IV.), ten minutes and upwards was spoken of for vulcanising a sheet of $\frac{1}{16}$ of an inch in thickness, according to whether the temperature employed was 370° or less; but the thin films which are sufficient to render a cloth waterproof can be thoroughly converted by exposure for one and a half to two minutes in a chamber heated

to 290° or 300°. For such articles as these a large stove or chamber heated by hot air, in which the goods can be freely extended, is the most convenient apparatus. Small articles may be rapidly converted at a higher temperature by passing hot irons or cylinders over them.

As to giving the reader a full detail of all the appliances of the vulcanised rubber, it would be simply bewildering. This may be sufficiently gathered from a study of the contents of the window of one of the many shops belonging to the principal manufacturers, and which are exclusively devoted to the sale of these goods. Besides these, however, there are many articles which do not generally appear in shop-windows.

Elastic bands and carriage springs have already been incidentally mentioned. The former belongs to a large class of small applications which administer to one's daily convenience, such as the washers in the lids of portable ink-stands, soft and indestructible toys for children, braided elastics for pocket-books, purses, umbrellas, wristbands, garters and braces, trouser-straps, sponge-bags, bungs, stoppers, ink erasers, balls, and a great variety of others not to be despised. Some of these are made of sheets cut either in the ordinary way or by stamping into the form required. Others are made in moulds, such articles being very commonly moulded prior to vulcanisation, and then converted by the agency of heat before being withdrawn from the moulds. The material is very frequently forced while warm into the mould by the application of considerable pressure; but sometimes when a hollow article is required it is deposited from a solution; in the latter case, after a certain thickness has been gained, the rest of the liquid is poured off and a fresh supply introduced, so as to add a second layer, and so on until the required thickness is gained. The moulds may be made of metal in one or more pieces, though glass is sometimes used with advantage. To prevent the rubber from adhering to the surface of the mould, it is usually dusted over first with finely ground silicate of magnesia. All kinds of devices may be cut into the surface of the mould, which will produce figures in relief upon the exterior of the articles made in them.

FARMING AND FARMING ECONOMY.

By Professor Wrightson, Royal Agricultural College, Cirencester.

XVIII.—SHEEP.

INTRODUCTORY REMARKS—LONG AND SHORT-WOOLLED SHEEP—COTSWOLDS—LINCOLNS—ROMNEY MARSH—LEICESTERS—BAMPTONS—SOUTH-DOWNS—HAMPSHIRES—SHROPSHIRES—OXFORDS—DORSETS—EXMOORS.

It is difficult to conclude as to the relative importance of cattle and sheep. Both are eminently useful to man, and each is fitted to fill its own peculiar place in our rural economy. Cattle occupy the best grazing land, and the clay land districts of the country; they also are reared in large numbers upon the moors and hills of the west and north. Sheep are found in every part of the country, but are peculiarly associated with light lands, and high mountain tracts, where cattle do not find a congenial home. In the present series we have treated of mixed husbandry, where arable land is carried on simultaneously with the rearing and fattening of live stock. It is, then, with the relations of sheep to arable farming that we have particularly to do, and in contrasting them with those of cattle under similar circumstances, we observe the following differences:—Cattle require housing in winter, while sheep will fatten readily out of doors in the most inclement seasons. Cattle require their "roots" to be carted from the field to the homestead, while sheep eat their swedes where they were grown. Cattle-feeding entails the use of straw as litter, and expensive haulage of the manure produced during the fattening stage to the field. Sheep require no litter, and their manure is spread exactly where it is wanted. Cattle require very constant attention, while sheep, although also requiring great care and supervision, are, on the whole, more independent. Cattle (except in the case of milch cows) yield only one commodity—beef; while sheep yield a constant supply of wool, as well as mutton. These considerations point out sheep as a more profitable stock than cattle, where the situation is congenial. Where land is light and dry, then all the advantage of feeding root and forage crops off the ground by means of sheep may be realised; but where land is stiff, the treading of sheep, instead of doing good, does harm. Under these latter circumstances, it is much the best plan, if roots are grown at all, to cart them off, and consume them by means of cattle in sheds, and such heavy lands are especially benefited by the farm-yard manure made by cattle. It is for these reasons that we find the cultivators of stiff lands leaning to cattle as the best medium for changing their root-crop into money, while sheep husbandry, on the other hand, has become characteristic of light land tracts. It has been proposed to accommodate sheep to heavy soils by shed-feeding them instead of cattle, and this can be done with good results, provided the sheds are airy, and the sheep are not overburdened with wool.

In giving some account of sheep husbandry, we find in the first place that a large number of breeds divide the country among them. We shall, therefore, in the first place, and as briefly as possible, give the leading characters of the principal races, and then make some remarks upon the rearing and fattening of sheep. Sheep are commonly divided into long and short-woolled races, while others have been described as middle-woolled. This character of length of fleece is accompanied by traits which are worthy of attention. Thus, the long-woolled races are usually heavy in the carcase, suitable for low-lying and rich pastures, somewhat coarse by comparison in their mutton, long and heavy in their fleeces, white on the head and legs. Short-woolled sheep, on the other hand, are smaller and lighter in the carcase, well adapted for downs and sub-mountainous tracts, yield a very high quality of mutton, a short and fine wool, and are brown, or even black, on the face and legs. The principal long-woolled races are the Cotteswolds, Lincolns, Romney Marsh, Leicesters, and Bampton breeds. The short-woolled sheep are well represented by the Sussex and Hampshire Downs, the Shropshires, Dorsets, Exmoor, and numerous other Down races co-extensive with the chalk range. The Cheviot sheep may be mentioned as a middle-woolled race, exceedingly useful in the locality after which it is named, as well as for crossing purposes.

Cotteswold sheep are found in the greatest perfection upon the hills after which they are named. These form an elevated tract in Gloucestershire and Oxfordshire, and extend into Worcestershire and Somerset. The sheep, it is said, have conferred their name on the hills, rather than the hills on the sheep. In mediæval times the wolds were covered with "cotts," or sheds in which the sheep were housed in order to protect their wool from injury in inclement seasons—hence "Cotteswolds." These sheep have partaken of the general improvement in all kinds of live stock, and were in the earlier part of the century crossed with the New Leicesters. They are now improved by selection alone, and may be thus described. The Cotteswold sheep stands high on his legs, and carries a heavy carcase and a grand head. The face and legs are, as a rule, white, but spots of grey are not considered as indicative of impurity of race. The face is wedge-shaped, wide between the eyes, and black skin, where it shows at the nose and eyes. Pinkness of skin on the nose indicates delicacy in this breed as well as in Leicesters. The head is surmounted by a top-knot, or long lock of wool hanging over the eyes, and always looked for in a sheep of any pretensions to merit. The neck or scrag must be tapering from the shoulders to the head, be full and thick, and have a good crest; the shoulders must be level with the back, wide between the blades, smoothly laid and graduating easily into the neck, without abruptness or coarseness; the animal must be thick through the heart, from blade to blade; the bosom must be deep, wide, and prominent; the ribs well sprung; the back broad and level; the hips and rumps (quarters) well carried out to the tail, and level with the back and shoulders; the thighs well developed inside and out, giving good legs of mutton; the carcase deep, long, and wide; the legs well set on "at the four corners;" the hocks and knees strong, and the sheep upright on his pins; the fleece heavy, thickly set, and characterised by a rather bold and large curl. The Cotteswold is next to the improved Lincoln in size, and may be readily brought to twenty-five pounds per quarter at ten months old. The fleece, under ordinary circumstances, will weigh from eight to ten pounds, but extraordinary weights, rising to double those just given, are not uncommon in good flocks. High prices are given at the ram sales which are held annually on the hills. Above 20gs. has been given, and averages of £25 to £26 have been realised. There is a considerable export trade, and during the last two or

three years a great impetus has been given to the breeding of rams by the increased colonial demand.

The *Lincoln sheep* has for long occupied the rich pastures of its native county. It, like the Cotteswolds, has been improved by the importation of Leicester blood in the proportion of about 1 to 3. The Lincoln is the largest and heaviest fleeced sheep we possess, and instances are on record of sheep having weighed eighty to ninety pounds per quarter. Captain Catlin, of Needham Hall, Lincolnshire, has furnished us with particulars of a Lincoln two-shear sheep, whose carcase weighed 274 pounds. A correspondent writes:—"I enclose two staples of the wool which I drew from two fleeces as they lay upon the winding board: by measuring you will find them 20½ inches in length, and you will remark how strong is each individual fibre, and how well the strength is maintained throughout. At my request, three of the fleeces were weighed; they were as follows:—No. 1, 20 pounds; No. 2, 18½ pounds; No. 3, 20½ pounds. I do not, of course, wish you to suppose that I chose any but the best I could lay my hand upon; but I have no hesitation in saying that there were many sheep in the pen that would clip as much or more wool." Mr. Kirkham, of Audley, writes in March, 1870, after a bad season:—"There is a considerable demand for Lincolnshire sheep for exportation to Australia and Buenos Ayres, and their worth seems to be gradually, although slowly, appreciated. This is not to be wondered at when a good Lincolnshire hog in his wool is worth £6, but to arrive at this result, they must be well cared for from the first."

The Lincoln, in many respects, closely resembles the Cotteswold sheep, but is furnished with a less prominent top-knot, and is straighter along the top, carrying the head somewhat lower. The wool is exceedingly long, and has a peculiar glistening appearance, which has earned for it the name of "lustre wool." This peculiarity is, however, restricted to sheep bred and kept in Lincolnshire.

The *Romney Marsh* form another tolerably distinct breed, although something of the "professional eye" is required to discriminate between them and the last-named race. They are a heavy-carcased, long-woolled, hornless, white-faced breed, with a considerable admixture of Leicester blood in their composition, and are well suited to the low-lying and rich pastures at the south of Kent, known as Romney Marsh.

The *Improved Leicester sheep* owed its origin to the care bestowed upon the original county breed by the celebrated Robert Bakewell, of Dishly, Loughborough, Leicestershire. This noted breeder brought out an improved race of cart-horses, the once celebrated long-horn cattle, and, lastly, the Leicester or Dishly sheep. The improvement was effected by selection alone, and under this system, rigidly carried out, the old breed was reduced in size and rendered more symmetrical, its fattening tendencies were greatly enhanced, and early maturity was encouraged. Whereas formerly sheep were fattened at three, or even four years old, under Bakewell's management they could at last be made ready for the butcher at from ten to fourteen months old. Very little is known of the plan pursued by Bakewell in making these improvements. He communicated his knowledge to few, and for long the best blood was retained by a clique known as the "Bakewell club." The Leicester sheep is less in size than either the Cotteswold or Lincoln. His wool is shorter and less abundant, his top-knot either entirely wanting, or scant, and the animal is characterised by greater compactness and firmness of touch than the preceding races. The Leicester has extended over the whole kingdom, and has been exported to all parts of the world. It possesses the useful property of retaining its characters under very varied conditions of soil and climate, and has been crossed with a large number of local breeds. Thus, in Scotland, the Cheviot and Leicester cross is highly esteemed; in the north of England the same sort of cross-bred sheep are very prevalent. In Durham and Yorkshire, "mules" bred between Leicesters and the Black Faced Mountain breed are justly popular as a hardy race, well suited for wintering upon grass land, and fattening the succeeding summer. In Lincolnshire we have already noticed the effect of the union between Leicesters and the Old Lincoln, and the Romney Marsh and Cotteswold sheep need not be further commented upon as good instances of the same policy. The Leicester has also been very successfully crossed with Sussex and other downs, and the result has been a large-framed, strong-constitutioned sheep, combining the advantages of plenty of wool and first-rate mutton.

As a pure breed the Leicester is probably not so much in demand as formerly, and it is rather the fashion to speak of it as having had its day. There is, however, so much of rivalry among the promoters of the various breeds of sheep, that ill-tempered remarks may often be attributed to this cause.

The *Bampton* breed is found in Devonshire and Somerset, and may be generally spoken of as a long-woolled, white-faced, hornless breed, suitable for rich valley pastures.

SHORT-WOOLLED SHEEP.

Foremost among these is the *Southdown* or *Sussex Down*, native to the chalk range which extends to the east and west of Brighton. It is the most beautiful race of sheep in the country, and when exhibited at our great shows, never fails to attract the admiration of the public. The modern Southdown owes its improvement to the Ellmans of Glynde, in the last and present century. Arthur Young, in his agricultural tour, noticed the improvement which had then been effected in the old Sussex sheep, and since that time great pains has been taken to further develop the breed by such men as the present Duke of Richmond, the late Lord Walsingham, the late Mr. Jonas Webb, Mr. Rigden of Hove, Mr. Pinnix, and other well-known breeders. The Sussex down is of very symmetrical appearance, and the beauty of its form is the more apparent on account of the shortness of its fleece. The face and feet are fawn-coloured, and the head has much of the character of the fallow-deer; the eye is set in a not too prominent orbit, the crown is well covered with closely applied wool; the wool comes well forward upon the cheek, but it is not permitted between the eyes and nose; the "chap," or under jaw, is clean, or free from flesh; the fleece is short, and firm "as a board," showing cracks down to the skin when the animal turns. The remaining points relating to the general form of the carcase are similar to those looked for in other well-made sheep. The Southdown is a great favourite with butchers, as the mutton invariably pleases the consumer; accordingly a higher price by a halfpenny or penny per pound is given for these sheep. It is, however, not in high favour with tenant-farmers as a "rent-paying" sheep, but is more frequently in the hands of men of rank and fortune. It has been said to be essentially a "gentleman's sheep." The South-down loses some of its characters when bred for several generations away from the short, sweet pastures of the South Downs, and breeders have to go back to the hills for fresh blood, in order to maintain the standard of their flocks.

Hampshire Downs are a larger, coarser-looking, slightly longer-woolled race of sheep, with darker faces and legs than the last, and originated, according to Mr. E. P. Squary, in a cross between the old Wiltshire horned sheep and the old Berkshire knot with the South-downs, which were introduced into Wiltshire and Hampshire early in the present century.

From 1815 to 1835, the Hampshire Downs of North Hants and those of South Wilts were, owing to the different conception as to what constituted a good sheep, totally dissimilar in character. The Wiltshire sheep was larger, perhaps less handsome, and not so uniform with respect to colour as those of Hampshire, and an ewe with speckled face and ears was not necessarily draughted, provided she was possessed of other good points. To Mr. Humphry, of Oak Ash, near Newbury, is due, in a great measure, the present character and position of the Hampshire Down sheep. This agriculturist effected its improvement by careful crossing with the largest and best fleshed of the Babraham South-down flock. This means, applied with wonderful ability, and at a great cost, has at length resulted in the present perfect animal.

The *Shropshire* breed has of late come prominently into notice, and is doubtless the rising sheep of the day. Although now only improved by breeding *inter se*, these sheep originated by crossing the old Morfe sheep with South-downs, Leicesters, and Cotteswolds. The character of the Shropshire has not been so uniform as could have been wished, on account of the varying proportion in which long-woolled and short-woolled sheep had been used in bringing out certain strains of blood. Hence some flocks had a long-woolled, and others a short-woolled character. Latterly, the Shropshire judges have insisted upon a uniformly dark, or almost black face, with a firm "helmet"

of wool extending unbrokenly between the ears, and on to the forehead. No "grey" hairs are allowed in the wool, and these are looked for near the tail. The carcase is heavy and square, the legs short and widely set. Shropshire sheep are found in almost every county, and are extending rapidly in public favour.

The *Oxford Down* has many points in common with the Shropshire, and the uninitiated might find difficulty in distinguishing one from the other. One of the best points of difference is the top-knot, which in the Oxford down is composed of a long lock of wool, as in the Cotteswold sheep. The face of the Oxford has also a bolder expression, owing to its Roman form of nose, and is more usually mottled, while the best Shropshire type is uniformly dark. The Oxford Down originated in a cross between the Cotteswold ram and the Hampshire sheep.

The *Dorset* sheep is white-faced, horned, and short-woolled; the ewes are peculiar for dropping their lambs exceedingly early in the winter, and thus providing the London market with the earliest supplies of lamb.

The *Exmoor* sheep resembles in general appearance that last noticed, and furnishes mutton of very high quality.

TECHNICAL DRAWING.—LXXXVIII.

DRAWING FOR METAL-PLATE WORKERS.

IN Fig. 640 the development of a square prism is brought under the notice of the student.

The mere development will, of course, be easily understood, since it is precisely the same as that of a cube, four of the faces being elongated instead of being square.

The object of the present lesson, however, is to show the section line on the development, thus enabling the workman to cut the metal out whilst flat, so that when bent, not only the general shape of the object may be formed, but the aperture caused by the section, and the covering of that aperture (which will be the true section), may be the result.

The section plane enters at the top, on the diagonal $a\ c$, and emerges at the angle a' of the bottom.

Draw the diagonal $a\ c$ in the square $a\ b\ c\ d$ representing the top of the present development.

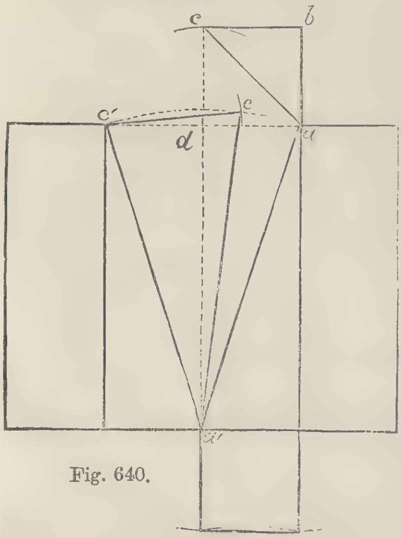


Fig. 640.

Now it will be clear that a is one of the points from which the section line is to be drawn, and also that when the development is folded into its proper form, c' would reach c; c' is thus another of the points of the section line, and a' will be the third.

Draw $a\ a'\ c'$, which will be the line of section.

The covering for this aperture will then be an isosceles triangle, of which $a\ c$ is the base, and $a\ a'$ and $c'\ a'$ the sides.

In a material which may be bent, it may be economical to make the whole development in one piece, and therefore the present method is shown.

From a', with radius $a'\ c'$, describe an arc; and from c', with radius $a\ c$, describe an arc cutting the previous arc in e.

Join $e\ a'$, $a'\ c'$, and $c'\ e$. Then the triangle $c'\ e\ a'$ is the required covering of the aperture.

Fig. 641 is another development of the same square prism, showing the section line caused by a plane passing from a line joining the middle points of two adjacent sides of the top to a similar line joining two opposite edges of the base. The method of procedure is as follows:—

Having drawn the general form of the development, draw the diagonal $a\ b$, and the line $c\ d$ parallel to it, the points c, d being the points of bisection, or the middle, of the sides of the square.

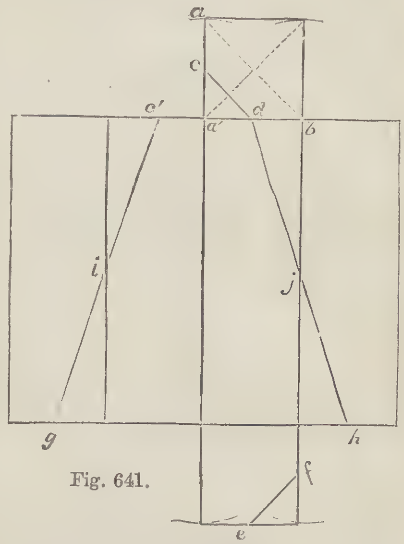


Fig. 641.

Draw a corresponding line at the opposite angle of the square representing the other end of the prism—viz., $e\ f$.

From a' set off $a'\ c'$ equal to $a'\ d$—viz., the middle of the width of the face—and find the corresponding points g, h on the edges of the base.

Draw $c'\ g$ passing through i, the middle point of the perpendicular, and draw $d\ h$ passing through j, and these will be the section lines.

Fig. 642 is the true section The width at top and bottom are of course equal to $c\ d$, and the width across the middle is equal to the diagonal of the square. To find the height, draw a side elevation of the prism, marking on it the section line, the length of which will be the height required.

Fig. 643, which has been given in an elementary manner in lessons in "Projection," and is here introduced in order that the further working out of the figures for the special use of metal-plate workers may be given, shows the plan and elevation of a piece of square metal piping, when the plane of the section passes from one side to the other at 45°: the section will thus be a rectangle, the length of which is equal to the section line, whilst the width corresponds with that of the side of the pipe.

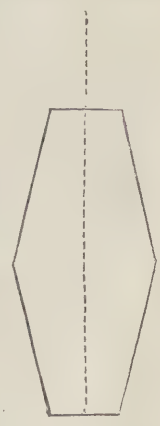


Fig. 642.

Now, if when such a pipe has been cut through at 45°, the upper portion is turned round, rotating, as it were, on a pin fixed in the centre of the section, the two parts meeting on the line $c\ d$ will form an elbow joint.

In the present example the joint forms a right angle, because the section line was made at 45° (that is, *half* a right angle); but an elbow of any angle may be formed by the same method, it being understood that the angle of the section line must always be half the angle required to be formed by the joint.

Fig. 644 is a projection of the object when placed at an angle to the vertical plane.

To draw this figure, place the plan at the required angle to the intersecting line, and draw perpendiculars from all its angles.

It has already been pointed out that when an object is rotated horizontally without its inclination being altered, its height is not altered. This may be frequently seen in the objects around us; for instance, a door, however much it may be moved on the line of the hinges, remains the same height; the uppermost extremity of a crane, when it is rotated so as to bring a cask or bale which has been raised from a vessel over the wagon waiting to receive it on shore, remains the same height, describing, in fact, as it moves round, a horizontal circle in the air.

Thus, then, this elbow joint, so rotated, is the same height as when its side was parallel to the vertical plane, as in Fig. 643. It is only necessary, therefore, to draw horizontals

from Fig. 643 to cut the perpendiculars drawn from the angles of Fig. 644 to complete the projection.

Fig. 645 is the development with the shape of the section attached.

Set out, in the first place, the four sides of the prism, with the ends, one only of which is shown in the figure.

On this development, draw across one side a horizontal line from *c* in Fig. 643.

From *d* draw a horizontal line, which will give the height of A B C D (Fig. 647) is the plan, and E F G H is the elevation of the pipe.

Draw I J and K L, the section lines as seen in the side elevation.

It will be clear that if the middle part, I J L K, were removed, the upper part, G H K L, could be brought down upon E F J I, and form a straight pipe as in the last lesson, and thus that the change is merely caused by rotating the middle piece, I J L K, as on a pin in the centre of each section, the upper and lower

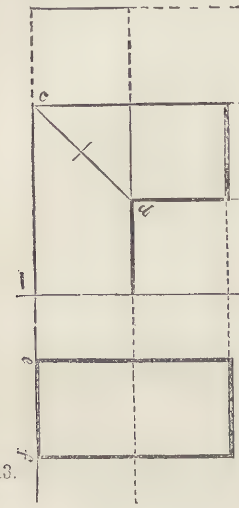


Fig. 643.

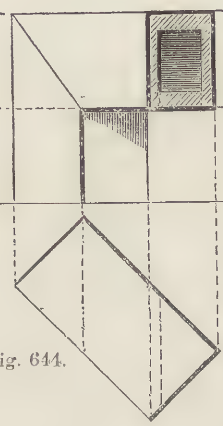


Fig. 644.

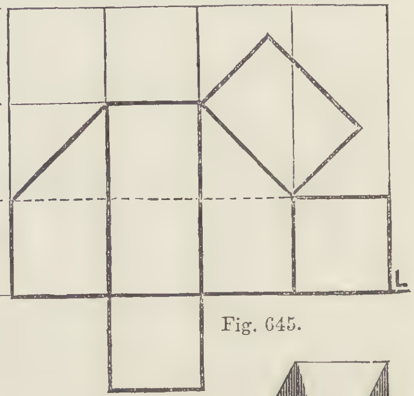


Fig. 645.

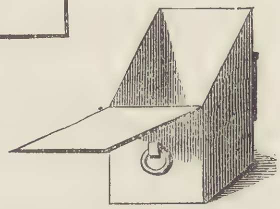


Fig. 646.

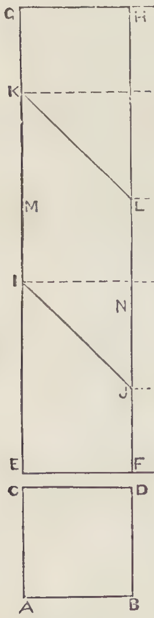
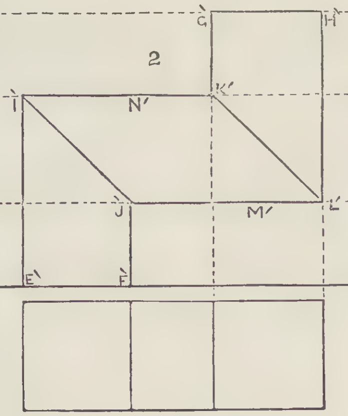


Fig. 647.



Fig, 648.

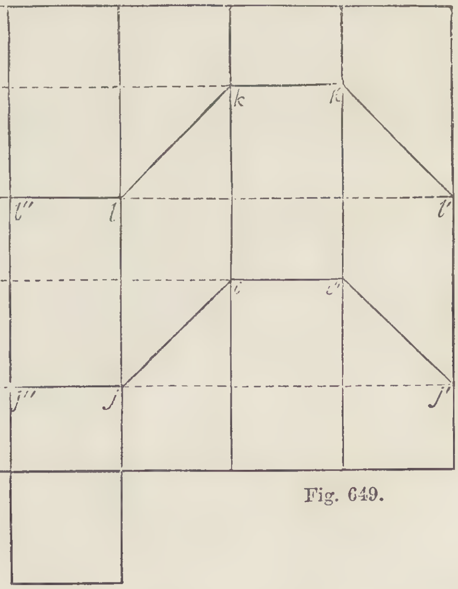


Fig. 649.

the right-hand face. Join these points by oblique lines, on one of which construct the rectangle representing the true section; and this would form the lid, if one of the parts were formed into a common coal-scuttle, as shown in Fig. 646.

In Fig. 645, it will be seen, there would be no waste of metal. The section line would so divide the plate that each portion would form a part of the pipe, the only difference being that in the part shown in fine lines, the joint will be one of the edges of the *back*, whilst in the other it will be in the *front*.

The method of obtaining the development and section line of a square pipe cut so as to form a double elbow will now be given in continuation of this study.

parts remaining vertical during the operation. This will be easily understood if a similar model be made of three pieces of wood.

When, therefore, this middle piece is rotated in the manner described, the lines M and N of Fig. 647 will take the positions of M′ and N′ in Fig. 648, whilst the lower portion, E′ F′ J′ I′, will occupy precisely the same position as in Fig. 647, as will also the upper part K′ L′ G′ H′, excepting that it is moved towards the right side and lowered.

Fig. 649 is the development showing the section line, which being constructed in precisely the same method as Fig. 645, will not require any further explanation.

ENGLISH CARRIAGE-BUILDING.—V.

BY A LONDON COACH-BUILDER.

LINING AND TRIMMING (*continued*).

We may with advantage say a word to our carriage lace-makers, who seem to have made but scant use of the Schools of Design, for the improvement of their taste in producing new and suitable patterns in the manufacture of their goods. For a long period we had nothing but the old scroll or flower pattern, which was handed down from father to son as if by a fixed law. At length, when it was felt that some change was required, the absence of all taste in design was shown in the production of entirely plain worked laces, which deprived carriage linings of their chief element of lightness and beauty. Thanks, however, to the taste and discernment of Messrs. Whittingham and Walker, who perhaps have devoted more attention to this branch of industry than any other house in London, the trade was relieved from the necessity of either adhering to the old pattern or of adopting the opposite extreme. They introduced small neat designs in laces, eminently adapted to the purpose, and in 1857 they registered a pattern now extensively known as the double diamond pattern, which has not only become general in England, but is largely patronised throughout Europe and America. This and kindred patterns exactly fulfil modern requirements, and give us the necessary relief without extreme.

But with materials well and tastefully selected, the trimmer has still his work to do. The lining of a carriage is divided into many different parts, all of which have to be designed. Canvas or paper patterns have to be cut to these and properly fitted, before the material is touched with which the carriage is to be lined. Wherever superiority of workmanship is to be shown in this department, the French method of trimming is adopted as being more elegant than the English: we shall, therefore, confine our observations to this method.

In adopting the French method, silk is mostly used in the place of morocco, and its peculiarities consist in the manner of quilting. The different squabs are made up in horizontal pipes or flutes, which are tufted in different ways. To proceed, cut a pattern of strong paper the size and shape of the space to be trimmed, and draw on it with pencil the pipes, also mark the position of the tufts. On large pieces mark only one half, the other half being the same. The pipes of the back are usually twelve inches high, and from three to five inches wide.

The position of the tufts is considerably varied. Next stretch a piece of strong muslin in the stuffing-frame, lay the proper pattern on it, and mark the place of the tufts with a round awl. Mark the lines of the pipes on the muslin with pencil or red chalk. In the same manner the pattern must be transferred upon the inside of the material used for covering, making, of course, due allowance for the depth of the pipes. About three inches is a fair average for fulness at top, one inch for the height of the pipes, and an inch and a half for the width. For the last pipe an extra allowance is made in a narrow strip sewed on to it.

Next lay a quantity of hair on the frame, and form with it the swell desired. Keep the hair in position with a few long stitches, and lay the silk over it. Commence tufting in the middle of the lower row of pipes, and continue equally to both sides. Silk cords stretched into the channels between the pipes were at one time considered elegant, but their main merit was that they aided materially in preserving the original shape of the pipes. Backs are usually made couch-shaped, with a roll all round on the top, which at the same time form the elbow-pieces on the sides. In elegant carriages this roll is often elaborately executed in a screw-like shape, and continued from the door-pillar down to the seat-frame, being made by winding silk cords around the roll. These silk cords appear as a single thread, but in reality there are three different cords, which are wound at even distances. A style of trimming much used of late, both in France and Germany for low backs, is a row of pipes at the lower end, which are pinched to points at the top, and above these are three rows of regular squares. Squares are preferred to diamonds, as they are softer.

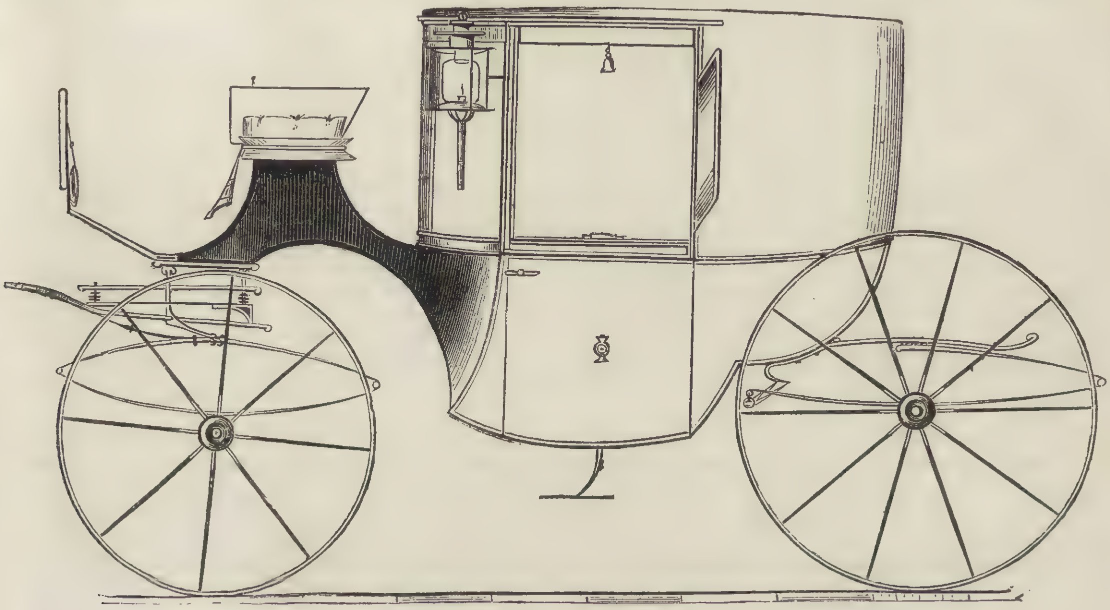


Fig. 9.—THE DOUBLE BROUGHAM.

Usually the back is laid on spiral springs, which are fastened as follows:—The back of the body is covered with coarse muslin, after being slightly stuffed, and on this muslin four rows of seven small springs each are set. For the lowest row, springs a little stronger may be used than for the other row. The highest row is set about an inch and a half below the edge of the back board, and the lowest row at six inches above the seat-frame. The springs having been sewn on with a bent needle, are tied first from right to left, and then from top to bottom. A thin cord will answer for this purpose.

The cord is first cut in lengths, and when the tying begins and at the end about six inches of cord are allowed. The cord is wound about the third ring of the first and last spring in each row, and afterwards the first ring is brought into the right position with the piece of cord allowed over. This will make the spring stand upright, and it can be raised or lowered on one side. The springs being thus all placed in position, they are finally tied cross-ways.

The squab, in this instance, is worked on coarse muslin, or

canvas stiffened with a little thin paste. It is set in the frame, and marked as we have described above. When the cushions press against the back and side pieces, frequently no stuffing is made, but simply a piece of fine linen is sewed reverse to the main piece, and this is called the "false finish." In fine work the stuffing extends clear to the seat-frame.

Of course each of these variations requires a different calculation for the muslin at the back as well as for the cover. For the latter an allowance of an inch and a half is made for the pipes from the lower to the upper end, and also for the points an addition of three-quarters of an inch. For each square in the height an inch and a half has to be calculated. The folds of squares, when laid over springs, being diagonal, easily draw apart when stretched out, while the folds of diamonds running up and down may be drawn tighter to a certain degree of stretching.

For the upper row of squares we have to allow for the backs at least double what we have to allow for the other rows—namely, three inches. For the width of every pipe an addition of an inch and a half is calculated.

Both cover and muslin being thus marked, we commence to draw in the tufts; every point marked on the cover has to lay exactly on the corresponding one of the muslin. The lowest tufts are first drawn in, then turn the frame and commence on one side at top, every point of the pipes being singly stuffed and the folds adjusted. This being done, every row of the squares can be tufted right through, stuffed and folded. Squares are easier to be worked than diamonds; but pointed pipes give more trouble than the ordinary straight ones.

The elbow-pieces of this finish consist of two rolls made of muslin; they are thinner towards the front of the seats. After being stuffed, a piece of muslin eight inches wide is sewed on all the length to the bottom of the roll, which serves after the roll is tacked to the door-pillar and the back to give it the required sweep in stretching and tacking it to the sides of the body. Then mark on the roll the width of the pipes and cut the cover for it, allowing one inch of width; and as to the height, the cover must go all round, the roll having to be sewed back and front to the linen with which the roll is tacked to the body.

After we have put in all the lining we have to adjust the silk curtains, the blinds and glasses to doors and front part, to cover the iron dash-frame with best patent leather, trim the coach box-seat, put on all the mouldings and beadings to the body, arrange the position of the lamps and fix them, and generally attend to all those little finishing points which give an appearance of neatness and finish to the whole, and at length we have the complete carriage as represented by our illustration in the preceding page.

We often hear purchasers express their surprise that pleasure carriages should be so costly; but when they come to acquaint themselves with all the details of their production, with the heavy investment of capital in the first instance by the manufacturer, the expensive nature of the materials used, the time, care, anxiety, trouble, and experience, together with sound practical knowledge involved, we think their surprise will considerably diminish; we think, moreover, they will see the necessity, in their own interests, of avoiding cheapness in such adjuncts to their establishments, and of placing themselves, in such matters, in the hands of builders of acknowledged reputation. For ourselves, we can confidently say, as the result of long experience, that nothing is more costly than an ill-built carriage, and its costliness is a continual source of annoyance and irritation to its owner, whereas the first outlay on an equipage well and soundly constructed, and elegantly finished, brings to the purchaser a constant feeling of pleasure, security, and comfort.

GREAT MANUFACTURES OF LITTLE THINGS.—XII.

LOCKS (*continued from Page 287, Vol. III.**).

BY CHARLES HIBBS.

BRAMAH introduced his celebrated lock with an essay, entitled, "A Dissertation on the Construction of Locks, containing, first, reasons and observations, demonstrating all locks which depend upon fixed wards to be erroneous in principle, and defective in point of security; secondly, a specification of a lock constructed on a new and infallible principle, which, possessing all the properties essential to security, will prevent the ruinous consequences of house robberies, and be a certain protection against thieves of all descriptions." This performance has long been out of print, but it has been quoted from in every subsequent work upon lock-making that is worth reading. The principle of his new lock was illustrated by a diagram, showing how the parts were made to lock into each other, a matter which we must endeavour to make clear by a written explanation.

The reader can, if he pleases, construct a model for himself with very little trouble. Take a common cardboard box, of the sort that jewellers use, and cut in each end a small perpendicular slit from the bottom upwards to a little more than half the height. In this insert a slip of cardboard long enough to project beyond the ends of the box, so that it can be worked backwards and forwards with the fingers. We will call this the bolt of the lock, and so far there is nothing to impede its motion. Cut now other slits in the *sides* of the box from the top downwards, to a little more than half the depth. They must be opposite to each other, and may be of any convenient number, say three on a side. In line with these three nicks must be made in the top edge of the longitudinal slip. If three shorter pieces of cardboard be now inserted in these slits, and pressed down until their edges catch in the nicks of the bolt, it is clear that the latter will no longer work backwards and forwards. But if corresponding notches have been made in the lower edges of the transverse slips, these when brought together in the line of motion of the longitudinal slip, will allow it to pass as freely as before. In making the slits and notches, a piece must be cut out neatly with the penknife, so that the slips may have some play, and the model may work easily. The cross pieces being now drawn backwards a little, the bolt will be locked, and cannot be moved until the three notches are pushed into line again. If they are drawn back to varying distances, and the ends then trimmed to a level, each one will require to be pushed forward a longer or a shorter space accordingly, in order to bring the three notches into line. The experimenter may now, if his model be rigid enough for the purpose, proceed to construct a key. Another piece of cardboard, the length of the box, may have its edge cut into steps so regulated in height, that when pressed against the ends of the cross pieces, and pushing them forward until the two outer steps rest against the side of the box, the whole may be brought to the unlocking position. A little further trouble will convert the model into an amusing puzzle. Place a lid upon it, glue small pieces of wood or pasteboard on the ends of the slips to prevent their being wholly withdrawn, and propose the problem of finding out the unlocking position without the aid of the key.

Bramah's cylindrical lock, with its little pipe-stem key, bears no outward resemblance to what we have described, but the principle of its mechanism is precisely the same. Only we must now abandon the fiction, convenient for the moment, of calling the longitudinal piece the *bolt*. In the real lock it would be called the *locking-plate*, and its form, instead of being an oblong square, would be that of a circular disc with a hole in the middle. The notches would be cut in the edge of the inner ring. Imagine one of these made of hardened steel, and cut in two halves across the centre. The barrel of the lock, turned and bored out of solid metal, has a deep groove cut round it, in which the edges of the locking-plate are inserted, and the two halves brought together. The plate being now securely bolted down, by pins passing through short pillars, to the case of the lock, the barrel will turn round upon it freely. But this barrel is composed of several parts, and the function of some of them is to prevent its turning round, as we shall see. First, there is the cylinder itself, a massive block of metal, with a hole drilled through the centre. A strong plate is screwed to the bottom, and on this plate has been turned an upright steel peg, which comes up through the hole in the cylinder, and forms the pin for the key. Radiating from this a number of deep slits are cut into the substance of the cylinder from end to end, far enough to reach and overpass the edge of the locking-plate, which lies in its circular groove. In these slits are inserted little pieces of steel, called sliders, which, filling the notches in the locking-plate as they are pushed down, effectually prevent

* This paper, having been mislaid, is now presented out of its proper turn.

the cylinder from turning round. The reader will readily conceive that the slides are also notched on their outer edges, and that at eccentric distances, so that they require to be moved forward to a greater or lesser degree to come to the unlocking position, like the slips in the cardboard box. When the lock is at rest, the ends of the slides are pressed up towards the keyhole by a helical spring which is coiled round the central pin, and which acts upon steps or shoulders cut in the sliders for that purpose. The key has a larger pipe than ordinary, and scarcely any bitt or projection. Round the end of the pipe are cut slots of varying depths, in which the ends of the sliders fit as the key is inserted in the keyhole, and which, pressing each down to the exact point necessary, bring the whole of the notches into the circular plane of the locking-plate, and enable the barrel to be turned round upon its axis by the pressure of the tiny stud on the side of the key. To increase the difficulty of picking, false notches are made in the sliders as well as the true ones, which alone are cut deep enough to allow of passing the plate.

It remains to be explained how the turning of the cylinder effects the passage of the bolt, which is an entirely independent limb. At the back of the base-plate which is secured to the cylinder is a small stud, which works into a curiously-shaped cavity in the hinder part of the bolt, so contrived that though the traverse of the stud will move the bolt backwards and forwards, no pressure applied to the end of the bolt will cause the cylinder to revolve. Usually, in applying locks of this construction to the doors of a safe, the massive bolts which secure them are not acted upon directly by the key, but are moved by a handle, and the office of the lock is simply to secure them in their position when the doors are fastened.

Such was the lock upon which Mr. Hobbs exercised his remarkable ingenuity in the July and August of 1851. In the window of Messrs. Bramah's shop in Piccadilly had been hanging for nearly half a century a padlock of their ordinary make, to which was appended a painted board, offering a reward of two hundred guineas to any one who should succeed in making an instrument that would pick or open it. The exact size of this memorable lock was as follows:—Width, 4 inches; thickness, $1\frac{1}{4}$ inch; over the boss, $2\frac{3}{4}$ inches. The cylinder was $2\frac{1}{4}$ inches in length by $1\frac{1}{2}$ inch in diameter. Negotiations were opened in proper form, and an agreement was drawn up, binding both parties to the following conditions:—The lock was to be enclosed between two pieces of wood, and secured to a wall in such a position that only the keyhole and the hasp were accessible. The true key was to be sealed up, and not used until the operator had either picked the lock or abandoned his enterprise. An iron band, sealed by himself, was to cover the keyhole when he was not at work. Thirty days were allotted him for the performance of his task, and three gentlemen of eminence in the scientific world—viz., Mr. George Rennie, Professor Cowper, and Dr. Black—were appointed to act as arbitrators between the parties. All these preliminaries being adjusted, the lock was removed from the window to an upper room of the establishment, and Mr. Hobbs commenced his operations on the 24th of July. Some little misunderstanding as to the terms of the agreement, which rendered necessary an appeal to the arbitrators, caused a suspension of the work for some days, but on the 23rd of August Mr. Hobbs showed the lock with the hasp raised, and shot the bolt backwards and forwards in the presence of Dr. Black and Professor Cowper. The true key, being afterwards applied, was found to work as usual, which proved that the works had not been injured, and the lock had been truly picked. The time actually occupied was spread over sixteen days, and Mr. Hobbs was in the room with the lock exactly fifty-one hours. It is fair to say that Messrs. Bramah, though, honourably submitting to the award of the arbitrators, and paying the money, did so under protest, on the ground that the spirit of the challenge had not been fairly complied with; but it is not our business here to recount all the historical circumstances of the affair. Suffice it to say, that the event proved as much the excellence of the lock as it did the ingenuity of the picker.

Let us now endeavour to comprehend the methods adopted by Mr. Hobbs in the performance of this difficult feat. His first care was to relieve the pressure of the helical spring, which, as we have explained, is continually forcing the ends of the sliders towards the keyhole. On the top of this spring is fastened a small plate or cap, of circular shape, which fits under the shoulders of the sliders, and enables the one spring to do duty for all. Mr. Hobbs made an instrument that would effect his purpose out of a piece of thin metal tubing that would just fit upon the central key-pin, filing the end into teeth that would pass between the sliders. With this he pressed upon the cap, and pushed down the spring as far as it would go. To keep it there he fixed a curved iron stanchion on the woodwork in which the lock was embedded, in such a position as to overhang the keyhole, and by means of a thumb-screw passing through it, held his instrument firmly in its place. A lever of very simple construction, with a bent end, enabled him to exert such a continuous pressure upon the barrel in the direction tending to unlock it, as would answer his purpose, and thus he was free to act upon the sliders. Of these there were no less than eighteen, and each had, besides the true notch, two or three false notches, sufficiently deep to allow of that play in the interior which would deceive the most delicate manipulator. Mr. Hobbs used no more elaborate an instrument than a common steel needle to push down the sliders, while a fine crochet hook was employed to pull them back. Having first ascertained which of the sliders was most bound by the pressure tending to rotate the cylinder, he pushed it very gently until he felt it very slightly relieved, by which he knew that the locking-plate was either in the true notch or in one of the false ones. That done, he felt round cautiously for the next tightest, and effected the same process with that, and so on with them all. We may conceive how exceedingly nice must be the sense of touch that would enable him to do this, when we remember the extreme minuteness of the parts, and their number, compared with those in the Chubb lock, which had so easily succumbed to the tentative process in the hands of the same operator. The Bramah lock, too, from its construction, admits of much greater exactness in the fitting of the several parts than the best form of lever lock; and this, be it remembered, was a test lock, made for the purpose of challenge by their most skilful workman, and certain not to contain any accidental defects. It will readily be imagined, therefore, that it was the patient work of days to relieve the sliders one after another, and having done that, to ascertain which of them had only got the false notches into position, the cylinder being still locked by them, and unable to revolve. It must also be remembered that Mr. Hobbs had to remove his instruments and leave the lock intact at the end of each day, the keyhole closed with a sealed iron band. He had thus to begin each morning's operations by adjusting all the parts to the position he had gained the day before, a work of considerable time. To facilitate this he took accurate measurements upon a fine strip of brass of the exact position of the sliders when he had succeeded in relieving them, and recording these measurements in a systematic manner, he had data upon which to proceed. At the end of the fifth day, according to Mr. Hobbs's own account, the cylinder gave to the pressure exerted upon it by the lever, and began slowly to revolve, showing that the true notches had all been got into position; but at the very moment of triumph some part of the apparatus—whether the lever or the toothed instrument that was pressing down the spring, does not clearly appear—was found to be too weak for its work, and the attempt had to be abandoned for that time. A stronger instrument was made and applied; the tentative process was carefully repeated, and the lock at length yielded to the siege.

It cannot be said that the result of this trial was calculated to weaken the reliance of the public on the safety of the Bramah lock. Under the most favourable circumstances, and conditions partly proposed by himself, a man singularly gifted for the purpose, possessing an intimate scientific knowledge of lock construction, and the most consummate artist in his line in the world, had succeeded in opening a lock after working at it, undisturbed and in secret, for several days. No burglar would ever have such a chance, nor is it easy to conceive any combination of circumstances that would give any fraudulent operator such a chance in ordinary life. One of the precautions taken by the Messrs. Bramah—that of embedding the lock between two blocks of wood—was really, as we have seen, an assistance to their antagonist, as it gave him the opportunity of fixing his iron stanchion, which he could not have done upon a safe-door; besides which, he got all the advantages of perfect rigidity, a matter of great importance in the extreme delicacy of his operations. The reward was technically, and no doubt

fairly, won, but the reputation of the lock was not sensibly damaged.

The honour of being the first to baffle the skill of this hitherto invincible lock-violator belongs to Cotterill, of Birmingham. His lock is a modification of the Bramah, the parts being differently placed, so as to offer greater obstacles to fraudulent manipulation, and having one or two additional safeguards, which no art has yet been able to overcome. The body of the lock, instead of being an upright cylinder or barrel, consists of a flat circular plate of some solidity, in which grooves are cut, radiating from the centre like the spokes of a wheel. In these grooves lie the sliders, at right angles to the action of the key, instead of being perpendicular to it. Each has its own little helical spring pressing it toward the centre, and the key being notched, not on the end, but in a sloping direction, to varying depths, on the side, pushes the sliders outwardly when pressed down. The locking-plate is a vertical rim of steel, coming up through the solid plate a little above the depth of the grooves in a circular channel cut near its outside edge. This rim, being notched to receive the sliders, allows them freely to traverse in a longitudinal direction; but being itself securely bolted to the outside case, does not permit the solid plate, with its system of sliders, to revolve until the notches which are on the under side of the sliders come all into correspondence with it. A cap covers all, and the general appearance is neat and workmanlike. Of course there are false notches to increase the difficulty of picking, as in all locks of the kind made since the tentative process became known. The inventor claims for his key an advantage which no other key possesses—viz., that it is impossible to take an impression from it, owing to its peculiar formation. He also states that by his method of manufacture he is enabled to ensure that among many millions of keys, no two shall be alike.

Mr. Hobbs attempted to pick this lock in 1854, being challenged to the trial by Mr. Cotterill, who had been aggrieved by some expression respecting his patent used by Mr. Hobbs in a paper read before the Society of Arts. In vain the American replied that he came to this country as a competitor at the Great Exhibition, and that he must not be supposed to be open to any challenge that was backed by a pecuniary inducement. Mr. Cotterill persisted, feeling that the reputation of his lock was at stake, and the trial at length came off at Manchester. The lock was one which had been sold in the ordinary course of business, not made for test purposes, and it had been some months in use in the office of a consulting engineer. The operator was allowed to take measurements of the keyhole, etc., and to construct an instrument in his own time, before the actual test began. At length, when all preliminaries were adjusted, Mr. Hobbs sat down before the lock, and proceeded to push back the slides.

The instrument he used was described in a newspaper account of the time as the most ingenious picklock ever seen. It had twelve radiating needles or wires, that being the number of the sliders in the lock, and each had a screw adjustment which enabled him to propel it forward to the requisite extent. He had undertaken to open the lock within twenty-four consecutive hours, and at the end of half that time he announced that he had got ten of the twelve sliders into position. This turned out to be an error, and the examination of the lock which took place after the trial convinced him that he had really made no progress at all. However, he was unable, with the utmost skill and patience, to push his success further than the point he supposed himself to have gained; and a few minutes before the expiration of the time, he quietly rose and said, "The lock's yours; I give it up." When the interior was revealed, Mr. Hobbs was forcibly struck with the ingenuity of the mechanism that had baffled him, and candidly owned that he was just as near picking it when he first put the instrument in as he was at the last moment. "A man," he said, "might work at it a lifetime, and not overcome it."

The feature which had proved impregnable was one of the additional safeguards of which we have spoken, and consisted of an exterior ring of steel, encircling the whole mechanism, and offering the resistance of a wall to the passage of the sliders outwards on their way to the unlocking position. Their ends struck this wall just before their notches got into the magic circle of the locking rim. It would appear, therefore, that the lock could not be opened at all; but this outer ring was perforated to admit the ends of the sliders, and would allow them to pass, provided the perforations were brought opposite to the grooves in which the sliders lay. When the lock was at rest they were not exactly opposite, but each overhung a little the nose of the slider, so as to oppose some part of the solid rim to its perfect passage. The nose of the slider was bevelled so that it would force itself in if it got sufficient entrance, and adequate force was applied; the rim moving slowly round to accommodate it against the pressure of a spring which tended to retain it in its normal position. But the peculiarity was that the perforations were so regulated as to position, overhanging the sliders by different degrees, according as these impinged upon the rim sooner or later, that it required the simultaneous movement of them all to effect the pressure requisite to move the rim. Mr. Hobbs's delicate manœuvres were no match for this! Had he been fortunate enough to have selected by haphazard that slider which in its passage first entered the rim, and tried the tentative process upon it as a commencement of his work, the force he must have exerted to get it into position when unaided by the others would have effectually marred his sensitive touch. "Really," said he, on inspecting it after the trial, "it is a very ingenious and pretty arrangement, and reflects great credit upon Mr. Cotterill."

We have now carried our inquiry as far as is useful, considering the purpose with which we set out. Very many locks are in the market, other than those we have described, which deserve commendation for their ingenuity, but the cursory notice we could afford them would make the conclusion of this paper a mere catalogue. If the reader has been tempted into an interest in the subject by these necessarily brief descriptions of the three distinctive classes of locks—warded, lever, and slide, which embrace an infinite variety of modifications—he will be well rewarded by studying Tomlinson's "Rudimentary Essay on Locks," or the larger treatise on "Locks and Keys," by George Price, from both of which valuable assistance has been derived in compiling these papers.

TECHNICAL DRAWING.—LXXXIX.

DRAWING FOR METAL-PLATE WORKERS.

The principles shown in the two preceding lessons are further developed in the present one. Here Fig. 650 is the plan and elevation of a hexagonal prism, to be cut off at an angle of 45 degrees.

The method of projecting the elevation from the plan will not require any explanation in this place, and we therefore at once proceed to show the method of obtaining the true form of the section.

Let A B be the section line cutting the edges of the prism in C D.

It will be clear that A B in the elevation is represented by *a b* in the plan, and that C and D represent not only the two points so lettered, but two lying immediately behind them; thus, C D in the elevation corresponds with *c d* in the plan, and it will be seen that c' and d' lie directly at the back of these.

Thus, then, whilst the length of the section will be equal to A B, its width will be $c\ c'$ or $d\ d'$.

These points being clearly understood by the student, the execution becomes easy.

From A and B draw lines at right angles to A B, and draw A′ B′ parallel to A B. Now from C and D draw lines at right angles to A B, cutting A′ B′ in 1 and 2.

On these lines set off from 1 and 2 the widths corresponding with c 3 c' or d 4 d' in the plan—viz., e 1 f and g 2 h.

Join A′ g e B′ f h A′, and the figure thus completed will be the true section.

It will be evident that if the upper part of the prism were rotated on the lower, the two parts would form an elbow as already shown.

Fig. 651.—In this figure the prism is represented as rotated on its axis, so that one edge faces the spectator, whilst in Fig. 650 the side $c\ d$ was parallel to the vertical plane of projection.

Horizontal lines drawn from A, B, C, D will give the view of the section in this figure; but it must be understood that this is not the *true* section, the form being apparently shorter, owing to the position of the section, which, of course, slants backward from the lower point.

Fig. 652 is the development of the prism, and on this the section line is shown. This is, as before, obtained by drawing horizontal lines from the points A, B, C, D in the elevation, to cut corresponding perpendiculars in the development.

The parts thus produced will, when folded into shape, be exactly equal.

The lessons thus given will, it is hoped, be sufficient to enable the student to adapt the system to prisms of any number of sides, and we therefore proceed to illustrate the system of developing the covering of pyramids. For the method adapted for triangular and square pyramids the student is referred to Lesson V. in "Projection," Vol. I., page 84. The information there given will serve as introductory to the following lesson.

Fig. 653.—A B C D E F is the plan and Fig. 654 is the elevation of a hexagonal pyramid, placed so that one of the edges faces the spectator, two of the sides of the base (B C and E F) being at right angles to the vertical plane of projection.

Fig. 654 is cut by a line parallel to the base, and it is required to find the true section of the pyramid when cut by a plane of which the line G H is the elevation.

Now it will be clear that in this position each of the lines in the elevation represents two edges rising from points similarly lettered in the plan, since in the plan the three distant angles of the hexagon are immediately behind the other three, and thus the lines b c O and f e O in the elevation represent not only two edges each, but the triangular side of the hexagonal pyramid contained between them—viz., B O C and F O E in the plan.

All sections of this pyramid, parallel to the base, are regular hexagons; therefore a perpendicular drawn from I to cut the plans of the edges E O and F O in i' and i will give i i', the one side of the true section; and lines drawn from i and i' parallel to E D and F A will be two more, and thus the whole plan may be completed.

Similarly, Figs. 655 and 656 are the plan and elevation of the same pyramid when rotated on its axis so that two faces are parallel to the vertical plane.

Here the section line is seen cutting the elevation of the *edge* of the pyramid in A, and a perpendicular dropped to cut the plan of the edge in A′ gives the radius of a circle which will contain the true section; from the centre, therefore, with radius O A′, describe this circle, and this, cutting the other five radii of the hexagon, will give the hexagon which is the true section, as in the last figure.

We now proceed to draw the development of this pyramid, and here it will be evident that the exact size

Fig. 654.

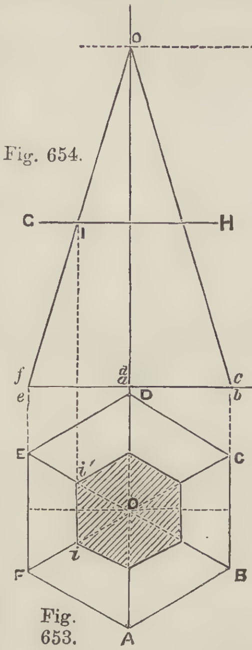


Fig. 653.

Fig. 656.

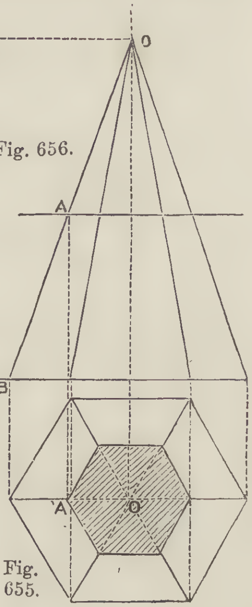


Fig. 655.

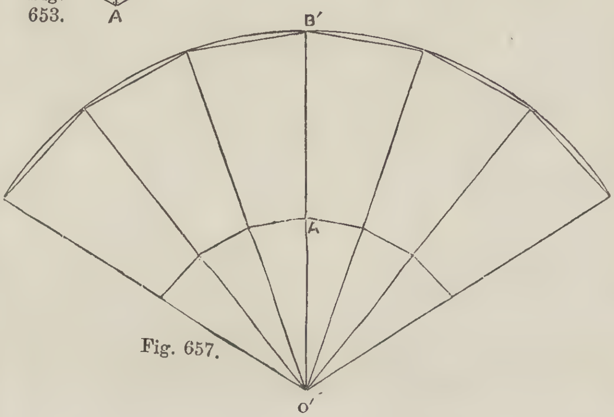


Fig. 657.

Fig. 650.

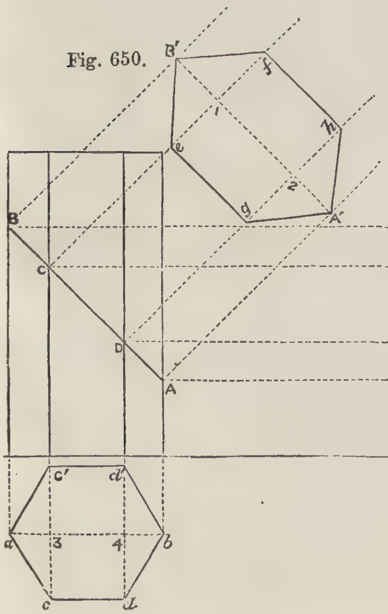


Fig. 651.

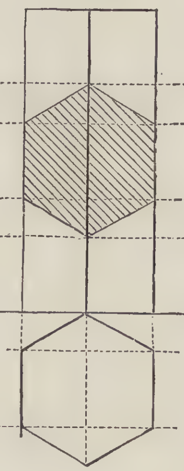
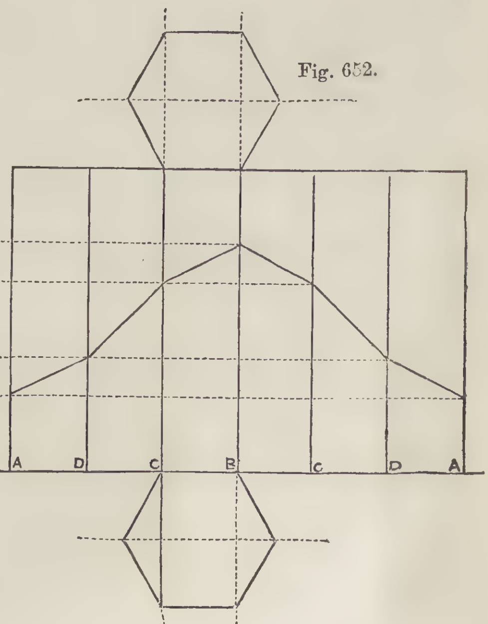


Fig. 652.



could not be obtained from the elevation (Fig. 654), for the length of *a* O is not the true length, because it slants backwards; nor is the length *f* O the right length, because the base on which it stands, F O in the plan, is not parallel to the vertical plane, and thus *f o* is in a degree foreshortened.

In the elevation (Fig. 656), however, the line B O is the true length of the edges of the pyramid; therefore, from any point as O′, with radius O′ B, describe the arc (Fig. 657), and set off on it six distances equal to the side of the hexagon forming the plan. From each of the points draw a line to O′, which will complete the development.

Now on each of these lines set off the length B A taken from Fig. 656. Join the points, and this will give the section line, thus completing the figure.

FARMING AND FARMING ECONOMY.

By Professor Wrightson, Royal Agricultural College, Cirencester.

XIX.—DAIRY HUSBANDRY.

Dairy produce consists of milk, butter, and cheese, and the practice of those who are engaged in the management of cows depends in a great measure upon the fitness of their locality for the production and disposal of one or other of these commodities. New milk is always saleable in populous neighbourhoods, and railways now bring it from even remote districts to the great centres of industry. The cattle plague during 1865-6 was an active cause in directing the attention of town dairymen to the plan now usually followed of drawing their chief supplies of milk from the country, and since that time of dreadful cattle mortality the character of the new milk business in London has become more that of importing than producing. This is in every way a change for the better, as there was but too much reason to believe that the highly artificial and forcing character of the feeding of town-kept cows, together with the inevitable confinement to which they were subjected, resulted in unwholesome and poor milk, as well as a high rate of mortality among the cows themselves. Some startling facts relating to the condition of the New York cow-stalls, which appeared in *Fraser's Magazine*, appealed both to the humanity and fears of the reader, and, no doubt, assisted the movement in favour of importation by rail rather than production in the town. The sale of new milk is manifestly the simplest method of disposing of the produce of cows, and where there is a demand no method will give so large a return. We have no wish to burden the reader with unnecessary statistics, but we may mention that a good cow may be expected to yield not far off 1,000 gallons of milk per annum, and that where large numbers of cows are kept, 600 gallons is looked upon as a very fair average. Taking this last figure as the basis of our calculation, and 1d. per pint or 8d. per gallon as a fair price, the produce of an average cow will be worth £20 per annum. The price at the present time (1872) in this neighbourhood (Redcar) is 1d. per gill or 2d. per pint, and the average produce of a cow is therefore £40 per annum, supposing this high rate to continue. No doubt rent of grass-land, price of extra food and of labour, risk of bad debts, etc., increase the cost of production in districts where such prices can be obtained; but in spite of these drawbacks the profits made by thrifty cow-keepers must be very considerable. The cost of maintaining a cow is very similar to that of keeping a fattening bullock, and a glance at the estimates already given under that head will show 7s. and 8s. per week to be a reasonable enough estimate, even where a fair allowance of extra food is given.

To properly understand the manufacture of those other familiar dairy productions—butter and cheese—we must very briefly consider the nature of milk. It is an emulsion of oily matters, principally composed of a solid and a liquid fat in a watery (whey) containing casein (cheese) and milk sugar in solution. The fat or oil is suspended as minute globules of from $\frac{1}{2000}$ to $\frac{1}{4000}$th part of an inch in diameter, and each globule is said to be covered with a coating of casein, which prevents it from coalescing with other similar globules. Cream is the aggregation of these globules upon the surface of milk that has been allowed to remain at rest, and is composed of fats associated with small quantities of water, casein, and sugar. The proportion in which cream exists in milk varies with the individual character of the cow, the race from which she springs, and the food supplied to her. Mr. Morton quotes an authority from Gloucestershire who says: "20 quarts of milk in hot weather yield 1¾ quarts of cream, or about 9 per cent. in volume, and one-fourth more or 11 per cent. in colder weather." The average yield of Mr. T. Scott's English dairies, quoted before the Agricultural Society, was 1 quart of cream for every 12⅕ quarts of milk, or little more than 8½ per cent. His Irish dairies yielded 10 per cent. With regard to the amount of butter obtainable from cream, Mr. Horsfall informs us that when at grass his cows yielded cream which gave at the rate of 1 lb. of butter per quart of cream; but that when fed in winter upon rape-cake, bran, and other substances rich in oil, their cream has yielded 22 to 24 ozs. of butter per quart. When milk is churned an average yield of butter is 1 lb. per 20 pints of milk, and the amount varies from 1 lb. per 17 pints to 1 lb. per 25 or 26 pints. The average amount of butter made from one cow in the year has been found in the case of numerous dairies to vary from 218 to as high as 300 lbs.

The manufacture or making of butter is at once so simple, and yet so dependent upon practical experience rather than knowledge which can be communicated by the tongue or pen, that we propose to treat of it with the utmost brevity. Agitating the milk or cream in any sort of vessel causes the fatty globules above described to break and agglutinate together into a mass of butter. The process is conducted in a variety of ways, but the same principle of action prevails in all. The barrel slung upon a frame, and turned with two winch-handles, is one of the most familiar forms of churn. The interior of this simple apparatus is fitted with perforated shelves extending from the internal surface towards the centre, through which the cream passes as the barrel is turned. Plunge churns, in which a plunger or piston, also perforated so as to allow of its free passage up and down through the milk, are also in use, and where large quantities of milk are employed this is a good churn for working by steam-power. Milk or cream may be allowed to become sour before it is churned without injuring the quality of the butter, but it is not advisable to add any sweet milk in such case at churning time. Milk rendered sour during the act of churning yields butter-milk that is liable to become rapidly rancid. Milk is churned at its natural temperature in summer, and is raised to 65° or 70° F. in winter by the addition of hot water. Cream is raised or lowered to 55° or 60° F. according to the weather. Churning proceeds with regular speed, turning the churn neither too fast nor too slow. When the butter falls from side to side in a compact lump the dairymaid knows that her work approaches completion, and when she is satisfied that all the butter is gathered together the mass is taken from the churn and washed with cold spring water, or carefully kneaded in a shallow, empty wooden vessel until all the butter-milk is removed. The butter is then salted with not more than 3 or 4 ozs. per 14 lbs., thoroughly incorporated by hand, and is then moulded and printed, or otherwise prepared for immediate consumption. Simple as these operations are, who does not know the uncertainty that attends them? Some dairy-maids are exceedingly fortunate in always obtaining butter of first-rate flavour and texture. Others as frequently fail, and so bring disrepute on the produce of their dairy. Occasionally the butter refuses to form, although churning may proceed for hours; while in other cases flavours more or less disagreeable, but difficult to account for, lurk in the butter produced. Experience, care, cleanliness, and attention to the feeding and the pasturage of the cows will usually ensure success, and when these essential points are attended to the risk of failure is reduced to a minimum.

The manufacture of cheese is more complicated than that of butter, and demands a fuller description. We cannot hope to touch upon the variety of practices followed in various districts, but must rest content with a sufficiently minute account of the method pursued in Gloucestershire, which is fairly representative. The chief cheese-making districts in Great Britain are Ayrshire, Cutherstone, Wensleydale, Cheshire, Stilton in Leicestershire, Gloucestershire, and Cheddar in Somersetshire. All these districts abound in first-rate old pasture-land, and it is only upon such land that good cheese can be made. The cows are very frequently of mixed breed, with the exception of the first-named district, in which Ayrshire cows are principally used. The Yorkshire cow, or ordinary unpedigreed shorthorn, is a great favourite, as giving a large quantity of milk of good

quality, and in a dairy of these cows an Alderney or two is often kept to add a greater richness to the general character of the milk. We shall consider cheese-making as at present carried out in the case of an ordinary Gloucestershire dairy, and afterwards turn our attention to another point of interest in the manufacture of cheese—namely, the introduction of the factory system from America.

Bearing in mind the composition of milk, it will be seen that butter and cheese are composed of the same constituents mingled together in very different proportions. Butter is the collected fats of milk associated with small quantities of casein, water, and sugar. Cheese is the casein of milk associated with butter, water, sugar, and ashy materials. The following analyses of various kinds of cheese taken from Mr. Morton's "Hand-Book of Dairies" will show at once their composition and the proportion which the ingredients bear to each other in every 100 parts :—

Ingredients per Cent.	Skim Milk Cheese.	Double Glo'ster.	Cheddar.	North Wilts.	N. Wilts. 2nd specimen	Dunlop.
Water. .	43·82	35·81	36·04	35·58	44·80	38·46
Casein. .	45·04	37·96	28·98	25·00	28·16	25·87
Butter .	5·98	21·97	30·40	30·11	23·04	31·86
Saline matter . .	5·18	4·25	4·58	6·29	3·99	8·81

Cheese-making consists in causing the separation of the casein from the slightly alkaline watery fluid in which it has been previously dissolved, and in doing so the more butter is precipitated with the curd the richer will the cheese be. This separation may be effected by natural means by allowing the milk to become sour, or by the introduction of an artificial ferment. This latter plan is followed, and the substance used is termed *rennet*. "It is essentially a decoction of animal membrane, or other animal substance in which a certain degree of chemical change has been permitted, and is, indeed, in progress." Calves' stomachs, either with or without their contents of curdled milk, are salted and packed away under the name of "vells." These vells are purchased in the winter at the rate of two for each cow, and six of them are placed in every two gallons of a saturated brine. A thirty or forty gallon cask may be prepared at once, and a constant supply of rennet be thus ensured.

Cheese-making may commence as early as the latter part of March, but more usually in April, and it is continued as late as October. Milk in early spring is used for feeding or fattening calves, or for butter-making, and is not considered very suitable for cheese. The cows are newly calved, and their milk is not suitable for the manufacture of cheese; the supply is also scarcely yet constant in quantity, and all these reasons cause cheese-making to be put off for awhile. We shall suppose then that April is well advanced, and that the work of cheese-making has become a regular daily employment. The utensils required in the cheese dairy are a cheese-tub large enough to hold all the milk of the cows; a "ladder" to lie over the tub; a straining sieve; skimming-dish; cheese vats or moulds turned out of solid elm wood; "suity boards," or round discs of elm made to fit the vats when there is not sufficient curd to completely fill them; a stone or iron cheese-press; shallow lead vessels for receiving the whey; pipes to drain off the whey to a cistern from which it is pumped into the pigs' troughs; usual vessels for milk and cream, and for butter-making.

The cheese-tub occupies the middle of the floor, and the morning and evening's milk is poured into it through a hair-cloth sieve. The following are the progressive steps in the operation :—

1. The milk must be brought up to the temperature of 80° F. by heating a portion, if necessary, in a vessel placed in boiling water. This is important, as, if the milk is too cold, the curd will be tender, and if too hot it will "heave."

2. The colouring matter or annatto is added, although this is less commonly done now than formerly.

3. The "rennet" is added in the proportion of half a pint to 50 gallons of new milk, or 75 gallons of skim milk.

4. A short time is allowed to elapse, and the curd which has now formed is cut in two directions at right angles to each other and around the edges with a long thin-bladed knife that reaches down to the bottom of the tub.

5. The curd is allowed to sink for a quarter of an hour, and some of the whey is dipped out, after which it is again slowly cut into very small pieces.

6. The curd now settles into a compact mass, and more whey may be removed.

7. Heap the curd into the middle of the tub bottom, which is convex.

8. The mass is cut through in several places to favour the escape of the whey.

9. Place the curd in vats, and subject it to pressure for about half an hour.

10. Break the curd into pieces about the size of vetches either by hand, or, better still, by means of a curd-mill.

11. The curd is once more placed in the vats, and a little scalding water thrown over it when the vat is full.

12. The "cheese" is now turned out of the vat or mould into a thick canvas cheese-cloth, and again placed in the vat completely enveloped in the cloth.

13. When the cheese has been two hours in the press it should be removed, and the wet cloth exchanged for a dry one.

14. The cheeses made in the morning are salted at night for the first time, and this is done three to four times by rubbing in the salt according to the thickness of the cheeses. Twelve hours should elapse between each salting.

15. The cheeses are turned in the vats every day, and remain in the press four days or longer. They are then taken out and placed upon the shelves, where they are also regularly turned and kept from draughts.

The various kinds of cheeses which divide the public favour owe their character to differences in the manipulation of the curd, the character of the pasture, and other less evident peculiarities in their manufacture. In Ayrshire the milk is heated to 85° or 90° F., when the rennet is added, and the consequence is a very rapid setting of the curd. Cheddar cheese is made by first adding rennet, as already described in Gloucestershire practice. The curd is afterwards finely broken and actively stirred in the whey, which is heated by drawing off a portion, placing it in a vessel in boiling water, and returning it to the remainder. This is done twice: the first time heating the whole mass up to 80° F., and the second time to 100° F. Half a pound per cent. of salt is added to the crumbled curd. A Stilton cheese is made from 9 gallons of new milk, and the cream of 2 to 3 gallons of milk. Lambs' stomach is used as the basis of the rennet, and when the curd is set it is not broken as in Gloucestershire, but is laid upon a canvas strainer in a cheese-basket. After a few hours, when sufficiently firm, it is laid in the vat in slices, and salt is sprinkled between each layer. Its own weight is sufficient pressure, and it is turned every two or three hours for the first day, and two or three times the next day. The cheese must remain in the vat three or four days.

Cheese-making is done once or twice a day, and entails an immense amount of labour upon the farmer's wife and daughters, as the burden of the operation falls principally upon them. It is this severe tax upon the household which has caused the recent movement in favour of cheese factories after the American models. In these factories the best methods may be adopted and carried out with an accuracy which can scarcely be looked for in a farm-house. Division of labour and constant practice will also greatly improve the skill of the manufacturers; strict economy in labour and material will be possible; while at the same time the farmer's family will be relieved of a severe and irksome responsibility. A most interesting report upon the Derbyshire Cheese Factory Association was contributed by Mr. Gilbert Murray to a recent volume of the "Royal Agricultural Society's Journal." The first cheese was made on the 8th of April, 1870, and the factory was in full operation upon and after August 28th. From this time to September 30th from 4,000 to nearly 5,000 lbs. of milk were daily received, and the amount of cheese made varied from 400 to nearly 500 lbs. per day, thus proving what has often been stated, that 1 gallon (10 lbs.) of milk makes 1 lb. of cheese. A cow in a well-managed dairy will yield from 4 to 5 cwts. of cheese in the summer, and about 10 lbs. of whey butter. The whey from a cow is sufficient to maintain one hog, and its value is estimated at £1.

GUTTA-PERCHA.—I.

BY GEORGE GLADSTONE, F.C.S.

DISCOVERY—ISONANDRA GUTTA—MODE OF COLLECTION—DESTRUCTION OF TREES—COMPOSITION—CHEMICAL PROPERTIES—PHYSICAL PROPERTIES.

THIS most useful substance was unknown in Europe until the year 1843, when it was almost simultaneously introduced to the public notice by Dr. Montgomery and Messrs. D'Almeida and Sons, of Singapore. Its resemblance to Indian rubber in many of its properties ensured for it a ready reception; and the enterprising manufacturers who had already applied caoutchouc to such a great variety of uses, took up the new article, and adapted it to various purposes, either in substitution for, or in combination with the former.

Gutta-percha is the inspissated juice of the *Isonandra Gutta*, a tree growing commonly in the island of Singapore, and on the Malay Peninsula, and in many of the principal islands of the Eastern Archipelago. It belongs to the genus *Sapotaceæ*, several of which yield a useful product, though none of the others will vie with the *Gutta*. The *Isonandra* frequently grows to the height of about seventy feet; and the trunk, which is always very thick in proportion to the height of the tree, sometimes attains a diameter of six feet; but trees of such dimensions are probably of great age, as it appears to be of very slow growth. The character of the foliage will be best understood by a reference to the drawing, which represents a portion of a branch with the leaves, flowers, and fruit. The wood is soft and spongy, and of a light colour, but traversed longitudinally by black lines which indicate the course of the channels that contain the juice; these lie immediately under the bark.

The plan of collecting the gutta-percha which was adopted at first by the natives was a very uneconomical one; but this was partly occasioned by the greatness of the demand which suddenly sprung up on the opening of the English market. This, and the very high price which it consequently fetched, incited the Malays to produce the greatest possible quantity at the time, regardless altogether of the future. They accordingly cut the trees down immediately above the root, and then cut rings through the bark of the prostrate trunk, about twelve to eighteen inches apart, from each of which the milky sap exuded. Cocoanut shells, or any other convenient vessels for collecting it, were placed under each incision; and as soon as the juice began to coagulate, which would happen after a few minutes' exposure, it was taken out and kneaded by hand into balls or lumps. Each tree would yield on an average about 15 pounds of gutta-percha.

So great was the destruction of trees in this way, the shipments from Singapore during the year 1848 being equivalent to the loss of 100,000 trees, that great fears existed at one time, lest the supply should be utterly cut off; and considerable exertions were made to establish the system of periodical tapping. The island of Singapore itself, which yielded the earliest supplies, was, as may be expected, very speedily denuded of all the gutta trees of any considerable growth; but explorations were made of all the most likely regions in the neighbourhood, and these showed that the trees occupy a very wide district, extending from Penang in one direction, to the south side of Borneo in the other, and that they often constitute a leading feature of the vegetation in the warm and moist alluvial lands lying between the hills and the sea-coasts. With a judicious mode of collection no fears need therefore exist on this score, though the price of the raw article may be such as to limit its application to those purposes for which it is specially valuable.

The milk is now very generally collected from incisions in the living trees, and worked up into blocks by the hand as already described. In some places where the juice is collected in large quantities, it is conveyed in bamboos to the boiling-house, and the watery portion driven off by the aid of artificial heat. The gutta is imported in cakes or lumps of very irregular size, just as they are made. These are of a variegated dirty brown colour, containing a good deal of dirt, chips of wood, and other impurities; even when not fraudulently adulterated by the natives for the sake of increasing the weight.

In composition it appears to be almost exactly the same as caoutchouc—a hydrocarbon consisting of about 89 per cent. of carbon, and 11 per cent. of hydrogen; and in many of its properties it also bears a strong resemblance, though greatly differing in others. Probably, in consequence of the rude way in which it is prepared, the gutta of commerce always contains more or less resinous compound, caused by the partial oxidation of the pure substance. A good sample of the ordinary article has been found to consist of the following:—

Pure gutta	79·70
Soft resin	15·10
Vegetable fibre	2·18
Moisture	2·50
Ash	0·52
	100·00

The analysis, deducting moisture and ash, giving—

Carbon	84·66
Hydrogen	11·15
Oxygen	4·19
	100·00

The pure gutta is easily separated from the rest by dissolving up the commercial article in any solvent, and then precipitating the gutta by adding alcohol, which will form a milk-white coagulum, consisting of the pure hydrocarbon. When thoroughly dissolved in such articles as bisulphide of carbon or chloroform it can be easily filtered; but this operation must be conducted under a bell jar, to prevent the evaporation of the solvent during the process. The filtrate will be quite clear and almost colourless, and when the solvent is allowed to escape, pure gutta will be left behind.

In chemical properties the two substances, caoutchouc and gutta-percha, bear a strong resemblance. The reader is here asked to compare the following points with those given respecting Indian rubber in Articles I. and II. under that heading (see pages 104 and 156), so as to save unnecessary repetition; and for convenience of reference they will be given as nearly as possible in the same form.

Insolubility in Water.—It is perfectly so in water at any temperature, a circumstance which will be seen to be of especial importance when we come to consider its application to oceanic telegraphy. Thus Professor Miller, in his report presented to the Committee of Privy Council for Trade on the decay of gutta-percha and caoutchouc, says—"As the general result of these inquiries, I find that whenever the gutta-percha has been completely submerged in water no injurious change has occurred, sea-water appearing to be eminently adapted to the preservation of the gutta-percha." The experiments from which this conclusion was derived were similar to those to which the caoutchouc was submitted, described in Article IV. All the samples protected by either sea or fresh water, and whether exposed or not to the action of air and light, were wholly unaltered after a lapse of nine months, "with the exception of a slight increase in weight, due to the absorption of water, which they lost again after the exposure to the air for an hour or two. The tenacity and structure of the material did not appear to have undergone the slightest change." Its impermeability to water at once suggests its possible value as a waterproofing material, its advantage over leather in the soleing of shoes, and its application to all those purposes for which Indian rubber had previously been used, and which depended upon this property.

Resistance to the action of Alkalis.—None of these, even when caustic, exercise any influence whatever; nor do any saline solutions.

Effect of Acids.—Like Indian rubber, it is rapidly decomposed by strong nitric acid, and slowly by concentrated sulphuric acid, but the other acids have no effect upon it. Even hydrofluoric acid will not touch it, so that gutta-percha bottles are ordinarily used to hold it, though it appears that the fluorine will notwithstanding find its way through the substance of the bottle in sufficient quantity to corrode the surface of any glass which may stand for any length of time in immediate proximity to it.

Sulphur produces upon gutta-percha an action analogous to the vulcanisation of caoutchouc; and as a manufacturing process of considerable importance, it will have to be spoken of in greater detail presently.

Insolubility in Alcohols and Fermented Liquors.—The similarity between the two substances holds good here also. The

former will scarcely dissolve pure gutta-percha, if at all; the commercial article will always be somewhat affected by it, because it is never free from admixture with a resinous product due to a slight oxidation of the gutta. No fermented liquors will attack it at all, and it will withstand the action of anything which tends to excite fermentation in other articles. Ether which is absolutely free from alcohol will dissolve it, but the effect of the least trace of the latter is as complete in this case as in that of Indian rubber.

Solvents.—Bisulphide of carbon and chloroform are the best, as they will act upon it in the cold. Benzole and oil of turpentine will do so to some extent at any time, but require the aid of heat to dissolve it completely. Linseed oil, whether boiled or not, Stockholm and coal tar, have no effect, but such as is of a preservative nature.

Oxidation.—We have in gutta-percha a strictly analogous instance of the effect of the direct action of the solar rays in promoting the absorption of oxygen from the atmosphere. Professor Miller found that "alternate exposure to moisture and dryness, particularly if at the same time the sun's light has access, is rapidly destructive of the gutta-percha, rendering it brittle, friable, and resinous in aspect, and in chemical properties. A gradual absorption of oxygen takes place, and the gutta-percha slowly increases in weight, becoming at the same time proportionately soluble in alcohol, and in dilute solutions of the alkalis." 500 grains of thin sheet gutta placed in an open bottle, but inverted, so as to be open to the air and light, but excluded from rain, gained in weight 24·5 grains in nine months, by the absorption of oxygen. "The outer layers of the sheet, where exposed to light, were brittle and resinous in appearance, but the inner portion, which had been screened from light by the outer folds, was but little altered in texture or appearance." 55 per cent. of the mass had been transformed into resin, while a similar sample in an open bottle, but kept in the dark, had only increased 2·5 grains in weight, and when treated with alcohol only gave up 7·4 per cent. of resinous matter.

In all these particulars gutta-percha will be seen to bear a very general resemblance to caoutchouc, but many of the physical properties will be found to be widely different.

Structure.—Instead of being gelatinous in character, and without any perceptible structure, gutta-percha appears under the microscope to be as full of holes as a sieve. This is easily shown by taking a drop of solution, putting it upon a glass, and then evaporating out the solvent; a thin transparent film will thus be obtained, in which the pores will be readily detected. If a drop of water is then added, it will be seen to find its way gradually into the cavities, which will become distended by the liquid.

Specific Gravity.—In consequence of its porosity, this is ascertained with difficulty. The commercial article is usually about 0·97, or a trifle lighter than water; but by manipulating it under water, so as to discharge the air from the pores, it will gradually become heavier, and ultimately cease to float.

BLOSSOM AND FOLIAGE OF THE GUTTA-PERCHA TREE.

Extensibility.—Though at first gutta-percha appears to be devoid of any fibrous structure, and is indeed but a coagulated sap, and therefore without any organic tissue, a fibrous character can be imparted to it, and it is then capable of extension in one direction to about double its original length, while if the tensile force is applied to what may be termed the crossway, it will break instead of yielding to the strain. In this respect, therefore, it bears no resemblance whatever to Indian rubber; and it is moreover practically devoid of elasticity.

Pliancy.—Herein lies one of its chief excellences, which renders its manipulation so exceedingly simple, and causes it to be applicable to such a variety of purposes. At the ordinary temperature of this climate, it has about the same tenacity and flexibility as leather of equal thickness; but as the temperature is raised it becomes softer, though still tough up to about 120° Fahrenheit; and when the heat is carried above 150° it becomes so soft and plastic that it can be easily moulded in any form, which it will strictly retain on cooling. Between that temperature and 240° it can be rolled out into thin sheets, or drawn out into threads, and will always return to its original firmness and tenacity on being cooled again. The greatest degree of cold ordinarily experienced in this country only slightly diminishes its flexibility.

Decomposition by Heat.—It burns readily with a bright flame. At 248° it melts; and on boiling it gives off abundant vapours, which condense into a colourless oil.

Non-conduction of Electricity.—In this respect it resembles Indian rubber, and is indeed equal to shellac as an insulator, while it has the advantage over the latter in not being brittle. It supersedes the former article in submarine telegraphy, as it possesses generally at least equal advantages, and can be manipulated with greater ease and less risk of loss of electric power from defective workmanship. So efficient is it as an insulator that it will retain its character under atmospheric conditions which would make the surface of glass a good conductor of electricity. When subjected to friction it becomes negatively electric. It is likewise a bad conductor of heat.

Its acoustic properties also stand very high, and on this account it is eminently fitted for the manufacture of speaking-tubes from one room or floor to another, which are now commonly used in manufactories and all large commercial establishments; while they are to be found occasionally in private dwellings.

It will be seen from the foregoing summary of the chemical and physical characteristics of gutta-percha, that while it has much in common with caoutchouc, it has at the same time sufficient specialities to render it a valuable help-meet to its elder brother; and in the sequel it will be found that while many of the manufacturing processes are almost identical, the fact of its readily yielding to a moderately warm temperature renders many of the operations much more simple and easy in their application than those which have to be adopted in the case of Indian rubber.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXV.—WILLIAM HARVEY: CIRCULATION OF THE BLOOD.

It has been remarked that contemporaries are seldom grateful to discoverers; and it is a striking corroboration of the truth of the remark, that only at this moment (1872) has it been decided to raise one of England's greatest scientific celebrities from the ungrateful forgetfulness to which he has been hitherto consigned. Such has been the world's treatment of the illustrious William Harvey, whose discovery of the fact of the circulation of the blood has given an imperishable glory to the name of Harvey, and placed him in the foremost rank of natural philosophers; but he who raised physiology from mere guesswork is at length to be honoured by the erection of a national memorial. A committee is in process of formation in London, to assist a committee at Folkestone, the birthplace of Harvey; and public scientific bodies and individuals are being asked for aid and co-operation. We gather from the report of a public meeting held at Folkestone, that Mr. Simon, the Medical Officer of the Privy Council, has warmly advocated the movement, and in the course of an eloquent speech made the following observations:—"Harvey, in teaching the fact of the circulation of the blood, in teaching what duty is done by each beat of the heart, in relation, on the one hand, to the function of respiration, and on the other hand, to the nourishment of all textures of the body, gave us our first groundwork of animal physiology. It is no exaggeration to say that in giving to the world that first precise knowledge of the circulation of the blood, he laid the indispensable foundations for all physiology that has followed or can follow; and surely this achievement by our countryman is something for us all to honour and be proud of." To this we may add that the Rev. Matthew Woodward, Vicar of Folkestone, and the churchwardens, are soliciting small contributions towards this national object. They propose "to fill the large west window of Folkestone Church with eight subjects chosen from our Lord's miracles of healing, and record, on a brass underneath, Harvey's great discovery, for which the whole human race has to be profoundly thankful."

William Harvey was born at Folkestone, in Kent, on the 1st of April, 1578, in a house of fair stone, which Harvey left by will, together with some land adjoining, to Caius College, Cambridge. At ten years of age he was sent to the grammar school in Canterbury; and having there laid a proper foundation of classical learning, was removed to Gonville and Caius College, Cambridge, and admitted as a pensioner in May, 1593. After spending five years at the university, to acquire medical knowledge, he travelled through France and Germany, and fixed himself, in his twenty-third year, at Padua University, where he diligently attended the lectures of Fabricius ab Aquapendente on anatomy, of Minadous on pharmacy, and of Casserius on surgery. He taught the existence of valves in all the veins of the body; and from that moment Harvey endeavoured to discover the use of these valves, his success in which inquiry was the foundation of his after fame. He took his doctor's degree at Padua in 1602, and returned home at the age of twenty-four; in the same year he again graduated at Cambridge, and settled in the practice of his profession in London. In 1604 he was admitted to the College of Physicians; and in 1615, when thirty-seven years old, he was appointed reader of the anatomical and surgical lectures at the College. He was next appointed physician to St. Bartholomew's Hospital [1619–1645], and the rules which he laid down for the duties of the medical officers of the hospital were adhered to for nearly a century after his retirement. ("Journals of the Hospital: Records of Harvey.") Writing of him, Aubrey says:—"His brother Eliab bought, about 1654, Cockaine House, now [1680] the Excise Office, where the doctor was wont to contemplate on the leads of the house, and had his several stations in regard of the sun or wind. He [Harvey] was much and often troubled with the gout, and his way of cure was thus: he would then sitt with his legges bare, if it were frost, on the leads of Cockaine House, putt them into a payle of water, till he was almost dead with cold, and betake himself to his stove, and 'twas gone." Harvey now seriously prosecuted his researches on the circulation of the blood, in the course of which he first publicly announced these doctrines; he read his lectures at the College of Physicians, in Amen Corner: and in the present College in Pall Mall East are seven preparations by him. Many years of experimental verification elapsed before he published these doctrines in 1628.

The importance of this remarkable discovery was great. Boyle, in his "Treatise on Final Causes," states that in the only conversation he ever had with Harvey, he was told by him that the idea of the circulation was suggested to him by the consideration of the obvious use of the valves of the veins, which are so constructed as to impede the course of the blood from the heart through these vessels, while they permit it to pass through them to the heart. Before the time of Harvey, the opinions on the circulation were numerous and inconsistent. The blood was supposed to be distributed to the various parts of the body by means of the veins, and that intended for the nutrition of the lungs by the action of the right side of the heart. According to the same doctrines, the arteries were destined for the conveyance of the vital spirits, which were formed on the left side of the heart from the air and blood derived from the lungs. Opinions did not agree as to the mode in which the blood found its way to the left side of the heart, some supposing it to be conveyed with the air from the lungs, others maintaining it to be transmitted by certain imaginary pores in the septum between the ventricles. These opinions, it is evident, rested more upon the imagination than any careful observations upon the facts. Those of Harvey, on the contrary, were drawn from the most accurate dissections of dead and living animals, and supported by arguments depending entirely upon the anatomical structure and obvious uses of the parts. Now there is historical evidence to prove that, although Harvey discovered the *fact* of the circulation of the blood, he did not discover the *course*, nor the *causes* of the circulation. He knew that the blood was carried from the heart, through the arteries, to the tissues, and from the tissues, through the veins and lungs, back again to the place whence it started. But he knew not *how* the blood passed from arteries to veins; he knew not *why* the blood thus moved. In our day, the exact course is known, but the exact *causes* are still under question. We know that the circulating system consists of heart, arteries, capillaries, veins, and lymphatics. Harvey knew not the capillaries and lymphatics. To estimate what he actually discovered, we will take a rapid view of the circulation.

The heart, as the great centre, shall be our point of departure. It is composed of four cavities, or *ventricles*. Into the right auricle the blood is poured by the veins; it passes thence into the right ventricle, and is driven therefrom, by a strong contraction called the *pulmonary artery*, into the lungs. Here it comes in contact with the oxygen of the atmosphere, and changes from venous into arterial blood. It now passes along the *pulmonary veins* into the left auricle of the heart, thence into the left ventricle, from which it is driven by a powerful contraction into the arteries. The pulsing torrent rushes through the arteries into the various tissues, where it passes into the network of capillary vessels. Having served the purpose of nutrition, the blood continues its course along these capillaries into the veins. Hence the stream is joined by that of the lymphatics, which, like the roots of a plant in the earth, absorb lymph from the organs in which they arise. This confluence of streams hurries on till the blood is emptied into the right auricle, from which it originally started; and thus is the circuit completed.

Still, the two centuries which have elapsed since Harvey's discovery have not sufficed entirely to complete it. Three capital errors, for sixteen centuries, marked the fact of circulation. First, that the arteries did not contain blood. Secondly, that the two chambers of the heart communicated with each other by means of holes in the septum dividing them. The third error was that the veins carried the blood to the various parts of the body. The first of these errors was, in part, set aside by Galen's proving that the arteries did carry blood; but the composition of the atmosphere being unknown in his days, it remained for modern science to prove that atmospheric air is not contained in the arteries, but only the oxygen thereof, with a slight amount of nitrogen, and a certain amount of carbonic acid gas. The second assertion, of the holes in the septum, was disproved in 1543, by Vesalius, the father of modern anatomy. The third error, that of the veins carrying the blood to the tissues, was disproved by Michael Servetus, showing that the two bloods, venous and arterial, pass one into the other in

the lungs, or by the pulmonary circulation. This he showed in a work which was burned by the theologians; and Servetus himself was subsequently burned for speculations of another kind. Servetus has plainly described the passage of the blood from the heart to the lungs, where it is agitated, prepared, and changes colour, and is poured from the pulmonary artery into the pulmonary vein. This, however, was but a guess, and was soon forgotten. Six years later, Colombo re-discovered the pulmonary circulation, and then Cæsalpinus, the famous botanist, unaware of what Colombo had written, announced the same discovery as his own, and was the first to pronounce the phrase "circulation of the blood." However, the true theory of *pulmonary* circulation remained for Harvey to discover. Servetus, Colombo, and Cæsalpinus, we have seen, knew that the blood passed through the lungs, but they conjectured that only so much passed as was requisite for the reception of the *vital spirits*, which, their predecessors fancied, passed through the perforated septum of the heart. They, however, had no conception of the entire mass of blood traversing the lungs. The discovery by Fabricius, in 1574, that the veins had valves, which opened and closed like doors, brought the discovery of the circulation within compass. These valves did not prevent any flow from the heart, but admitted it, which, it has been observed, ought to have suggested to the discoverer their use; but nearly half a century elapsed before the real object and purpose of this anatomical structure in respect to the blood-current was perceived. In the interim every anatomist of the great Paduan school in which Harvey studied was familiar with the circulation. Yet, when he promulgated its theory, it was ill received, most persons opposed it, others said it was old, and very few agreed with him.

No one, except Harvey, had for nearly half a century seen the significance of the fact; and he not only conceived a clear idea of the process, but described it minutely and accurately. Having, about the year 1620, succeeded in completely tracing the circle in which the blood moves, and having at that time collected all the evidence of the fact, with a rare degree of philosophical forbearance, Harvey still spent no less than eight years in re-examining the subject, and in maturing the proof of every point, before he ventured to speak of it in public. The brief tract, which at length he published, was written with extreme simplicity, clearness, and perspicuity, and has been justly characterised as one of the most admirable examples of a series of arguments deduced from observation and experiment that ever appeared on any subject.

Perhaps, during these eight years of re-examination, the discoverer of the circulation sometimes endeavoured in imagination to trace the effect which the stupendous fact, at the knowledge of which he had arrived, would have on the progress of his favourite science; and it may be, the hope and expectation occasionally arose, that the inestimable benefit he was about to confer on his fellow-men would secure to him some portion of their esteem and confidence. What must have been his disappointment when he found, after the publication of his tract, that the little practice he had had as a physician by degrees fell off. He was too speculative, too theoretical, not practical. Such was the view taken by his friends. His enemies saw in his tract nothing but indications of a presumptuous mind, that dared to call in question the revered authority of the ancients; and some of them saw, moreover, indications of a malignant mind, that conceived and defended doctrines which, if not checked, would undermine the very foundations of morality and religion. When the evidence of the truth became irresistible, then those persons suddenly turned round, and said that it was all known before, and that the whole merit of the vaunted discoverer consisted in having *circulated the circulation.*

But the epithet *circulator*, in its Latin invidious signification (quack), was applied to Harvey by many in derision, and it was believed by the vulgar that he was crack-brained. Nevertheless, about twenty-five years after the publication of his system, it was received in all the universities of the world; and Hobbes has observed that Harvey was the only man, perhaps, who ever saw his own doctrines established in his lifetime.

The opposition to the new system has, however, been greatly exaggerated by historians. It is true that the faculty rejected it, but eminent men adopted it. Guy Patin did not spare his opposition, which, however, Molière laughed at; and Boileau ridiculed the faculty. The great Descartes warmly espoused the doctrine. Swammerdam and Malpighi, two of the greatest names of the century, speak of Harvey with reverence, and soon no one spoke of him in any other tone.

The course of the circulation was not, however, known to Harvey; nor could he have traced it with the means at his disposal. But four years after Harvey's death, in 1661, Malpighi, by aid of the microscope, detected those capillaries which form the channel of communication between the arteries and the veins. Nevertheless, Leuwenhoeck, in 1668, discovered more than fifty circulations of the blood in different places in the tail of a tadpole. Leuwenhoeck saw that not only the blood in many places was conveyed, through exceedingly minute vessels, from the middle of the tail towards the edges, but that each of these vessels had a curve or turning, and carried the blood back towards the middle of the tail, in order to be conveyed to the heart. "Hereby," says Leuwenhoeck, "it appeared to me that the blood-vessels I now saw in this animal, and which bear the names of arteries and veins, *are, in fact, one and the same*, that is to say, that they are properly termed arteries, so long as they convey the blood to the farthest extremities of its vessels, and veins when they bring it back towards the heart." Thus, then, was the demonstration of the course of the blood completed.

In the whole of the circulation controversy, the discretion and rare modesty exhibited by Harvey afford the best model for naturalists and scientific writers. He had been so much disgusted by the disputes in which he was involved on the publication of his views on the circulation of the blood, that he had determined to publish nothing more, and it was only at the earnest request of his friend, Dr. Ent, that he was induced to allow his "Exercitationes de Generatione" to be printed. This work consists partly of a commentary upon the writings of Aristotle and Fabricius on the same subject, and partly of details of his own observations and experiments. We have not space for an abstract of these papers; but we may remark that Harvey was aware that the vitellus is drawn into the intestine of the chick shortly before hatching, and serves for its early nutriment; and in this relation he well compared it to the milk. This fact was known to Aristotle. He corrected the error of Fabricius, who supposed that the egg is chipped by the hen, and showed, on the contrary, that this process is performed by the chick itself. He also noticed the late union of the upper parts of the upper lip, and assigned it as a cause of the frequency of hare-lip.

In 1623 Harvey was appointed physician extraordinary to James I., with a promise of succeeding on the first vacancy to the physicianship in ordinary, the duties of which he actually performed. He was afterwards physician to Charles I., and was in the habit of exhibiting to him and the most enlightened persons of his court, the motion of the heart, and the other phenomena upon which his doctrines were founded. There is an anecdote current of Dr. Harvey attending a young nobleman, who, owing to a natural defect, had an open fissure in his side, through which the action of the heart might be watched, and the mode of the circulation demonstrated. The physician procured an interview with Charles, and explained the strange *lusus naturæ* infinitely to his satisfaction. His observations on the process of generation in mammalia were confined chiefly to the deer species, of which he was enabled to obtain numerous specimens by the liberality of Charles I., who allowed him to take them from the royal parks. Among Harvey's dissections was that of "Old Parr," who died at the age of 152 years and nine months; his body, by the King's command, was dissected by Harvey, who attributed Parr's death to peripneumony, brought on by the impurity of the London atmosphere and sudden change of diet. During the Civil War, Harvey travelled with the King, and at Oxford was made by him Master of Merton College, and received the degree of Doctor of Medicine. He held the Mastership for only a few months, when Brent, who had been expelled by the King for favouring the Parliamentary cause, was replaced by that party, which had now gained the ascendancy. Soon after, his house was plundered and burnt by the same party, and, unfortunately, several unpublished works —of which we have only notices in his other writings—were destroyed.

The latter portion of Harvey's life was chiefly spent at his country house at Lambeth, or at his brother's near Richmond.

The Doctor's visits to his patients were made on horseback, with a footcloth, his man following on foot, in the same way in which the judges were then accustomed to ride to Westminster. In 1654 he was elected President of the College of Physicians, but in consequence of his age and infirmities he was induced to decline that honourable office; but he testified his regard for the Society by presenting them with his library, and conveying over to them, during his lifetime, a farm which had been left him by his father.

He died June 3rd, 1657, in the eightieth year of his age, and was buried in a vault belonging to his family, built by his brother Eliab at Hempstead, in Essex, where a handsome monument was erected to his memory. Aubrey attended his funeral, and says:—"Hee helpt to carry him into the vault; that he is *lapt in lead*, and on his breast in great letters, Dr. William Harvey." This statement is perfectly correct, and Harvey's coffin is to be seen in the vault along with those of other members of his family. The shape of Harvey's coffin is curious: it resembles that of an Egyptian mummy-case, being of the human form without the appearance of the arms. It is entirely of lead; there is no wooden cover, and literally on the heart is the name of the deceased, as described by Aubrey. A few years ago, the tomb had fallen into decay, when various plans of restoration were proposed, but nothing done. There is a fine portrait of Harvey in the Library of the College of Physicians. He built also a museum in the garden, upon the site of the present Stationers' Hall; the original college buildings were destroyed in the Great Fire; and the college in Warwick Lane was taken down a few years since. The Harveian Oration (in Latin) is delivered annually by a Fellow, usually on June 25th.

Mr. Wharton Jones read to the British Association, in 1852, a paper "On the Forces by which the Circulation of the Blood is carried on," containing a physiological discovery of very great importance. In the wing of the bat the main impulse to the circulating fluid is, as in other animals, given by the heart; but, in addition, Mr. Jones has discovered that while the walls of the veins in this animal contract rhythmically, like those of the heart, and any regurgitation being prevented by numerous and appropriately-placed valves, they thus very materially assist in forcing the blood onwards.

TRADE-MARKS.—I.

By A Barrister.

WHAT THEY ARE: RIGHTS OF PROPERTY.

The subject of patents which we recently discussed has suggested the treatment of the analogous subject of trade-marks in a similar form. It is hardly necessary to explain to our readers what a trade-mark is, as a matter of fact. Every commodity capable of bearing a trade-mark, from bricks to bottled beer, bears a trade-mark if it be desirable to distinguish it from other commodities of a similar nature. The Legislature has defined what a trade-mark is to include, namely (25 and 26 Vict., cap. 88), "any and every such name, signature, word, letter, device, emblem, figure, sign, seal, stamp, diagram, label, ticket, or other mark as aforesaid lawfully used by any person to denote any chattel, or (in Scotland) any article of trade, manufacture, or merchandise, to be an article or thing of the manufacture, workmanship, production, or merchandise, of such person, or to be an article or thing of any peculiar or particular description made or sold by such person," and also "any name, signature, word, letter, number, figure, mark, or sign, which in pursuance of any statute or statutes for the time being in force relating to registered designs, is to be put or placed upon or attached to any chattel or article during the existence or continuance of any copyright or other sole right acquired under the provisions of such statutes or any of them." That is a sufficiently elaborate definition, but notwithstanding the many forms which a trade-mark may assume, the classes into which trade-marks may be divided are two only. The present Master of the Rolls, in a case of Hall *v.* Barrows, took considerable pains to go into the history of the subject, and he said, "Trade-marks are commonly either of one or the other of two descriptions—either they denote the spot where certain articles are manufactured, or they denote the persons by whom they are manufactured." Then it is to be observed that a mark or symbol alone is of no use; property cannot be acquired in it unless it is attached to a vendible commodity. This was fully discussed in the famous Anatolia liquorice case, before Lord Westbury, it being contended that there could be no property in the word Anatolia, as it was the geographical designation of a whole country. Lord Westbury dealt with the argument in this way:—"Property in a word, for all purposes," he said, "cannot exist; but property in that word, as applied by way of stamp upon a stick of liquorice, does exist the moment the liquorice goes into the market so stamped, and obtains acceptance and reputation in the market, whereby the stamp gets currency as an indication of superior quality, or of some other circumstances that render the article so stamped acceptable to the public."

The Lord Chancellor (1872), when he was Vice-Chancellor Wood, fully explained this principle in a case where a manufacturer claimed a right of trade-mark in certain numbers. His Honour said: "This Court has taken upon itself to protect a man in the use of a certain trade-mark as applied to a particular description of article. He has no property in that mark *per se*, any more than in any other fanciful denomination he may assume for his own private use otherwise than with reference to his trade. If he does not carry on a trade in iron, but carries on a trade in linen, and stamps a lion on his linen, another person may stamp a lion on iron; but when he has appropriated a mark to a particular species of goods, and caused his goods to circulate with this mark upon them, the Court has said that no one shall be at liberty to defraud that man by using that mark, and passing off goods of his manufacture as being the goods of the owner of that mark. And inasmuch as the Court protects the owner of the mark, he is entitled to authorise another, when he hands over his business to him, to place that mark on his goods. That is a right which, being protected by this Court, may be disposed of for value, may be bought and sold, and is therefore in that sense of the word property. The same may be said of a singer's voice. A singer may dispose of his voice by contract to one person, and the Court will prevent his disposing of that voice to another. The voice is in that sense property. Then, is not a man's name as strong an instance of trade-mark as can be suggested, subject only to this inconvenience, that if a Mr. Jones or a Mr. Brown relies on his name, he may find it a very inadequate security, because there may be several other manufacturers of the same name? But there is no evidence before me that any other person than the plaintiff has ever been heard of as manufacturing Ainsworth's Thread, and therefore 'Ainsworth's Thread' is as good a mark as 'Anchor Thread,' 'Lion Thread,' or any other which may be described by a particular name. The use, therefore, of the name of another manufacturer, whether done scienter or not, is an interference with his business, which this Court will interpose to prevent, on the ground that the defendant is endeavouring to pass off the goods of his own, or somebody else's manufacture, as the manufacture of the plaintiff."

The property in a name was carefully considered in the case of the *Belgravia* magazine, where the question was raised whether property of the character which is held in a trade-mark can be acquired in a name *before* the vendible articles bearing the name have been put upon the market for the purpose of sale. Advertisements of the title of the magazine had been issued extensively; and an attempt being made to use the name for a rival publication, the Court held that the persons issuing the advertisements had a trade-mark property in the name before publication.

The famous Reading sauce also affords a good illustration of this part of the subject. In the case of Cocks *v.* Chandler, the property in the use of the word "original" was largely discussed. In that instance it was urged that the word "original" is not like the word "chlorodyne" or "excelsior," and that a person could not be enjoined from stating, "I am the original inventor of the Reading Sauce," because, if originality consisted in having invented it only the day before, anybody may be an original inventor. It was there explained by the same judge whom we have already quoted (Lord Romilly), that if the person who uses the word is not the original inventor, then the word "original" is worth nothing. It is only in the character of being the first inventor that any person is entitled to the use of that word.

Having been dealing with the adoption of the same trade-mark by rival traders, we must now refer to cases of similarity. The general principles were laid down by the Lord Chancellor in the case of Seixo *v.* Provezende—that no trader can adopt a

trade-mark so resembling that of another trader, that persons purchasing with ordinary caution are likely to be misled, though they would not be misled if they saw the two trade-marks side by side; nor can a trader, even with some claim to the mark or name, adopt a trade-mark which will cause his goods to bear the same name in the market as those of a rival trader. But in these cases, as the Lord Chancellor remarked, questions of considerable nicety may arise as to whether the mark adopted by one trader is or is not the same as that previously used by another trader, complaining of its illegal use; "and," he added, "it is hardly necessary to say that, in order to entitle a party to relief, it is by no means necessary that there should be absolute identity. What degree of resemblance is necessary from the nature of things, is a matter incapable of definition *à priori*. All that courts of justice can do, is to say that no trader can adopt a trade-mark so closely resembling that of a rival, that ordinary purchasers, purchasing with ordinary caution, are likely to be misled."

We will now proceed to consider generally how a right of property in a trade-mark can be acquired so as to entitle its possessor to restrain interference with it. In a case to which we have already referred, Lord Romilly said: "The property which a manufacturer acquires in a trade-mark by the adoption of the use of it, is of a very peculiar nature." In an old case Lord Hardwicke doubted whether he could grant an injunction to restrain the use of a certain stamp upon cards, and that eminent judge is reported to have said: "Every particular trader has some particular mark or stamp; but I do not know of any instance of granting an injunction here to restrain one trader from using the same mark with another, and I think it would be of mischievous consequence to do it." Lord Romilly (late Master of the Rolls) discussed all Lord Hardwicke's reasons for his conclusions, and said, "It must be now conceded that some property exists in the use of a trade-mark, which at present is sufficient to support an action or maintain an injunction." He then proceeds thus:—

"It is clear, from a variety of decided cases, that a manufacturer who has originally stamped his goods with a particular brand, has a property in his mark at law, and can sustain an action for damages for the use of it by another. It is also clear that courts of equity will restrain the use of it by another person. It has sometimes been supposed that a manufacturer can only acquire such a property in a trade-mark as will enable him to sue for an injunction against the piracy of it by others, by his having enjoyed so long and continued a use of it as is sufficient to give it reputation in the market where such goods are sold. But I entertain great doubt as to the correctness of that view of the law. The interference of a court of equity cannot, it appears to me, depend upon the length of time the manufacturer has used it. If the brand or mark be an old one formerly used, but since discontinued, the former proprietor undoubtedly cannot retain such a property in it, or prevent others from using it. But, provided it has been originally adopted by a manufacturer, and has been continuously and still is used by him to denote his own goods, when brought in the market, and offered for sale there, I apprehend, although the mark may not have been adopted a week, and may not have acquired any reputation in the market, his neighbours cannot use that mark. Were it otherwise, and were the question to depend entirely on the time the mark had been used, or the reputation of it had been acquired, a very difficult, if not an insoluble inquiry would have to be opened in every case, namely, whether the mark had acquired in the market a distinctive character, denoting the goods of the person who first used it? The adoption of it by another is proof that he considers that at that time it is likely to become beneficial. If the manufacturer who first used it were not protected from the earliest moment, it is obvious that malicious and pertinacious rivals might prevent him from ever acquiring any distinctive mark or brand to denote his goods in the market, by adopting his mark, however varied, immediately after its adoption or change by the person who has originally used it. That evil would not be obviated by his putting his name in full, for if the name of the manufacturer was a common one, it would be difficult for him to point out to the public what goods were or were not manufactured by him. Those observations, in my opinion, apply to brands and marks generally; but it is essential to point out the distinction that exists between two different sorts of marks which I have already noticed—viz., the marks that denote the place where the goods are manufactured, and nothing more, and those which, on the other hand, denote the person who manufactured the marked goods, and nothing more." The learned judge then referred to a case in which the mark was the letters "M. C." branded on tin plates, made at certain works at Caermarthen. The letters had been adopted and used for a long series of years at those works, although carried on by different persons who succeeded each other. One of the lessees of those works, who had used the brand while he occupied the works, was held not to be entitled to restrain his successors from using the same brand. Lord Cottenham seems to have considered that the letters "M. C." denoted tin plates made at the works in question, and not those made by the plaintiff at any other place. "Assuming that to be so," remarks the Master of the Rolls, "then I apprehend that the mark or brand which denotes goods manufactured at a particular place may be, and probably would be, sold with the works themselves, and the mark would be as it were attached to the spot, to denote which it was first adopted, and which might possess peculiar local advantages for the manufacture of the article." We see clearly, therefore, the nature of the two classes of trade-marks, the one purely personal, the other purely local, and it will have been seen that the former attaches to the person so as to give the proprietor a right independent of locality, whilst the latter, as lawyers say, "runs with the land." Then the trade-mark must be honest, and applied to property of a specific kind. In the great case of the Leather Cloth Company against the American Leather Cloth Company, Lord Westbury said, "Where any symbol or label claimed as a trade-mark is so constructed or worded as to make or contain a distinct assertion which is false, I think no property can be claimed in it; or in other words, the right to the exclusive use of it cannot be protected." And as to the application of the symbols, his lordship said: "Property in a trade-mark is the right to the exclusive use of some mark, name, or symbol, in connection with a particular manufacture or vendible commodity; consequently the use of the same mark in connection with a different article is not an infringement of such right of property."

Before closing our consideration of the question of property, we must look at it very briefly, as it exists in partners and assignees. We have already shown that where the trade-mark consists of the name of a place, it passes from lessee to lessee without any assignment. But where the trade-mark is merely personal, as in the name of a person, or a title, design, or symbol, it can only pass by assignment. It was once doubted whether there could be any parting with the right to use a trade-mark, but that is now quite settled. This being so, another question arose—namely, how far, the trade-mark being parted with, others besides the purchasers are left in possession of it. And the principle established is this:—Although a trade-mark may include the name of a firm, the sale of that trade-mark will not preclude the purchasers of the business from using the name of the firm. But as regards a partnership—on a sale of a trade-mark, which is simply a design or symbol, it is lost as property to every member of the partnership. Several parties may be entitled to use a trade-mark, and wherever this is the case, a court of equity will use its power to protect them all.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLI.—SIR ISAAC NEWTON.

BY JAMES GRANT.

This illustrious philosopher was born on the 25th of December, 1642, in the manor-house of Woolsthorp, in the parish of Colsterworth, in Lincolnshire. Recent researches have proved that the family of this glory of his country and of his race came originally, during the reign of James VI., from Scotland, where the name is one of great antiquity. In the list of persons accused of treason in the records of the Scottish Parliament in 1568, appears William Newton of that ilk. His estate of Newton was in the constabulary of Haddington, and was bestowed upon a William Newton so early as the reign of Robert II., prior to whose time it belonged to the Swintons; but at the present time, there are upwards of sixty places in Scotland which bear the name of Newton.

Isaac was an only and posthumous child, his father having died a few months before his birth, in his thirty-sixth year. In 1646 his mother married a second husband, named Barnabas Smith, minister of North Witham, and her son was then left at his paternal estate in charge of her mother, who first placed him at a small day-school in the village of Skillington, from whence he was removed to another at Stoke, and in his twelfth year he was sent to the grammar-school of Grantham. In the house of Mr. Clark, an apothecary with whom he was boarded, the various chemical operations which he saw are supposed to have first awakened a taste for philosophical experiment and investigation in his youthful mind; and next a genius for mechanical inventions began to manifest itself in the construction of several curious pieces of workmanship, such as a clock and mill that went by water, and a carriage in which he could wheel himself round the room.

Geometry he studied deeply, making his way through the Elements of Euclid with such ease that he speedily became master of them. He remained at Grantham till the death of his stepfather in 1656, when his mother took him home to Woolsthorp, with the intention that he should superintend the farming of the property, and that he might lead the quiet life then led by English country gentlemen, after the storm of the great Civil War. But an occupation so humble had no attraction for Newton, and when, accompanied by a trusty servant, he was wont to attend the Grantham market to dispose of the farm produce, he used to leave the latter to attend the sale, while he seated himself book in hand by the wayside, or repaired to his old quarters at the apothecary's, where he would shut himself up among the works of the learned. Convinced at last that he would never make a good farmer, his mother wisely permitted him to follow the tenor of his own way.

Returning for nine months to the grammar-school of Grantham, at the expiration of that period, in June, 1660, a month after the restoration of Charles II., he proceeded to Trinity College, Cambridge. He was then in his eighteenth year.

There he applied himself to his studies, and especially to mathematical science with wonderful ardour, and though the statement may almost seem incredible, he appears actually to have completed all the splendid studies which have rendered his name immortal, within the *first* six years of his academical course. But then, says a writer, "there may have been minds as happily constituted as his for the cultivation of pure mathematical science; there may have been minds as happily constituted for the cultivation of science purely experimental; but *in no other mind* have the demonstrative faculty and the inductive faculty co-existed in such supreme excellence and perfect harmony."

In 1664 he purchased a prism for the purpose of trying some experiments suggested by a work of René Descartes; and the investigations upon which he thus entered, led him gradually to his great discovery of the composition of light, and the unequal refrangibility of the different sorts of rays, the doctrine from which nearly the whole of modern optical science is derived. Somewhere about the year 1666 he had invented his new instrument for calculation, the method of fluxions, that proud auxiliary to which physical science in so many departments owes its triumphs, and without which it would have been comparatively helpless; and it was in the same year that, having retired to Woolsthorp to avoid the plague which then raged at Cambridge, he was, while sitting in his mother's garden, first impressed with the theory of universal gravitation, by the simple incident of an apple dropping from a branch to the ground, from a tree that was only destroyed by the wind about 1830.

Concerning this popular anecdote, Brewster says (in his "Life of Newton"), that as it is mentioned neither by Dr. Stukely nor by Mr. Conduit, he did not feel himself at liberty to adopt it. We are told, however, that he immediately entered into the calculations necessary to verify the hypothesis he had formed, and would then have established its truth, had he possessed accurate measurement of all the distances to be considered; but being misled by incorrect statements, which prevented the result of his investigation from being what it ought to have been, it was not until some sixteen years after that, with rectified dâta, he resumed it, and brought it to a triumphant conclusion. Prior to this, in 1665, he had taken his degree of B.A., become a junior Fellow of the College a year subsequently, and graduated as M.A. in 1668, and in the same year obtained a senior Fellowship.

Dr. Barrow having resigned the chair of Mathematics, and accepted that of Divinity in 1669, Newton became his successor, and in January, 1672, was elected a Fellow of the Royal Society, to the *Transactions* of which he immediately began to contribute, and his papers on optics speedily drew upon him the attention of all the learned in Europe; but these, and other essays, involved him in many troublesome quarrels and literary controversies, which proved exceedingly distressing to one of a disposition so amiable, placid, and sensitive.

"I blame my own imprudence," he says passionately and regretfully, in one of his letters, "for parting with so real a blessing as peace, to run after a shadow!"

At last, he requested Oldenburg, the secretary of the society, to prevent, so far as he could, the appearance of any objections or philosophical letters that might be sent respecting his discoveries. He was also extremely averse to the publication of his "Principia," the grand disclosure of his philosophy of the universe, when the Society first urged permission to print it.

"Philosophy," he wrote to Dr. Halley, "is such an impertinent and litigious lady, that a man had as good be engaged in lawsuits as have to do with her." Eventually he yielded, and the work appeared in May, 1687. In this year he distinguished himself by his defence of the privileges of the University, against certain arbitrary attempts of James II. The Vice-Chancellor, and eight delegates elected by the Senate, had to appear before the formidable Ecclesiastical Commission; and one of those eight was Isaac Newton. "He was," says Macaulay, "the steady friend of civil liberty and of the Protestant religion; but his habits by no means fitted him for the conflicts of active life. He therefore stood modestly among the delegates, and left to men more versed in practical business the task of pleading the cause of his beloved University."

His activity, however, caused him to be returned as M.P. for it, in the year of the Revolution, and we are told that "among the crowd of silent members appeared the majestic forehead and pensive face of Isaac Newton: he sat there in his modest quietness, the unobtrusive but unflinching friend of civil and religious freedom." In 1690 he was one of those who voted for Sir Robert Sawyer at Cambridge, a fact which justifies us in believing that he had begun to see the headstrong and revengeful spirit of his own party, the Whigs, with disapprobation and concern. In 1695 he began also to take part in the discussion on the currency, and held many conferences on that important subject with Somers, Montague, and Locke; and in 1696 he was appointed from the office of Warden to that of Master of the Mint in England, an office then worth £1,500 per annum; and there his ability, industry, and strict uprightness produced a complete revolution throughout the department which was under his direction, though Pope writes cynically that Newton, "though so deep in algebra and fluxions, could not make up a common account; and whilst he was Master of the Mint, used to get somebody to make up the accounts for him."

He now relinquished the teaching of his class at Cambridge to Mr. Whiston, to whom he gave all the emoluments, and in 1703 he resigned his chair.

His residence in London was in St. Martin's Street, Leicester Fields, and after him it was long occupied by Dr. Burney, the eminent musician and historian of music. In the *Gentleman's Magazine* for 1814, it is described as a single building of six storeys in height; with "kitchen, parlour, first and second floors, garrets, and an *observatory*. Plan: passage to stairs on the right; on the left, rooms two deep. Elevation: between each floor plain strings, general cornice destroyed, a modern parapet, doorway, plain side pilasters, with scrolls, foliage and rich foliage: the dormer windows have pediments, the centre one a semi." And there, in that now squalid quarter of London, the great philosopher was living when he was again elected, in 1701, member for the University of Cambridge, defeating Hammond, who had been discovered at the famous supper in the Blue Posts Inn, and defeating him by a vast majority.

In 1703 he was elected President of the Royal Society, and not until the subsequent year—so much did he dread literary and scientific controversy—would he permit the publication of his work on "Optics." This was two years after the death of one of his most pertinacious tormentors, Hooke, who, while he lived, had almost regularly either contested the truth of every dis-

covery Newton announced, or went still further, and claimed it as his own. Newton was annually elected President of the Royal Society while he lived.

From Queen Anne, in 1705, he received the honour of knighthood, and the remainder of his life, save when engaged in the duties of his office, was spent, as the previous portion of it had been, in constant study, almost every department of science and of human knowledge receiving in its turn some new light from his singularly gifted intellect.

Newton died at his new home in Orbell's Buildings (afterwards called Pitt's Buildings), Kensington, on the morning of Monday, the 20th of March, 1727, in the eighty-fifth year of his age, and a short time before his death he is said to have uttered this memorable sentiment:—

"I do not know what we appear to the world; but to myself I seem only to have been like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"What a lesson to the vanity and presumption of philosophers!" exclaims Sir David Brewster; "to those especially who have never even found the smoother pebble or the prettier shell! What a preparation for the latest inquiries, and the last views of the decaying spirit, for those inspired doctrines which can alone throw a light over the dark ocean of undiscovered truth!"

His monument in Westminster Abbey stands on the north side of the entrance into the choir, and not far from it is that of Earl Stanhope.

MINING AND QUARRYING.—XXXIV.

BY GEORGE GLADSTONE, F.C.S.

MANGANESE.

DISTRIBUTION — ORES — VARIOUS OXIDES — QUANTITATIVE ESTIMATION—USES—GLASS-MAKING—BLEACHING-POWDER DYEING—DISINFECTANTS.

ALTHOUGH manganese as a metal is only known to the curious, its ores have a wide distribution, and constitute a very important branch of the mining industry of this country. Notwithstanding, it is only within the last 100 years or so that the ores have received any attention at all, and till after the close of the last century two or three mines in a limited district in Devonshire supplied the entire consumption of the United Kingdom. It is only since it has been employed in the manufacture of bleaching-powder, that the great demand for it has led to its being vigorously wrought. Devonshire alone now supplies some 5,000 tons of ore annually, but this is not one-seventh of the present consumption of the country. In addition to this, Cornwall supplies a good deal of ore, principally from the neighbourhood of Launceston; it is also found in considerable quantity in North Wales, Somersetshire, and Warwickshire, as well as in Aberdeenshire, and in Wicklow and other parts of Ireland.

In Devonshire the ores generally occur in the rocks of the Carboniferous and Devonian age, and both here and in Cornwall they are much associated with trappean rocks, though it seldom happens that they are found in the immediate presence of granite or elvan dykes. The localities most favourable, therefore, for tin and copper are unlikely to yield manganese, and the principal mines of this ore will be found to surround the granite region of Dartmoor in all directions, but at some little distance from the igneous rocks. The ore very commonly occurs in bunches, the best being usually contiguous to the trap, but sometimes rich deposits are found in the red sandstones undisturbed by any eruptive rocks; and at others it is found in association with hæmatite iron ore, either as branches from the band of iron ore, or as forming one wall of the lode, with hæmatite for the other.

The prevailing ore is called by mineralogists pyrolusite, which is the peroxide of manganese (MnO_2), generally more or less mixed with oxide of iron, silica, alumina, etc.; containing when separated from the other ingredients nearly two-thirds of manganese to one-third of oxygen. The exact proportions are 63·2 of the one to 36·8 of the other. It is often called the black oxide, on account of its dark colour, though more strictly it should be termed brown. Psilomelanite and braunite also occur in quantity in some places; they are the hydrated peroxide and the sesquioxide of manganese. The mines in Devonshire are usually very shallow, so that the ores are generally brought to surface by means of a common hand-whim, horse-power even being seldom required. Wad is the common name of an inferior ore, also a hydrated peroxide, which is obtained in large quantities, sometimes massive, and at other times forming a coating on other minerals. It is extensively used in the production of chlorine.

Manganese ores occur on a very extensive scale in some parts of Germany, especially in Hesse, and the districts of the Thuringerwald and Hartz. During the last fifteen years, however, a considerable proportion of our foreign supplies have come from Spain, as some of the mines in that country are favourably situated for shipping their produce; the ores are rich, and are found in pockets in a schistose rock. Austria, Italy, France, Sweden, Canada, and the United States of America may also be enumerated as sources of supply in case of need.

The ores of manganese may readily be detected by the fine red colour of permanganic acid, and the green displayed by the manganates. Thus if the substance to be tested is fused with carbonate of soda or potash, the manganate of the respective substances will be formed, and the product will be of a decided green colour. Again, if the manganate of potash is dissolved in a very small quantity of cold water, so that the solution shall be as strong as possible, it will appear a dark green, but as water is added to weaken the solution permanganic acid will be produced, and the green will gradually turn to a bright red.

The chemical combinations which it is especially important to bear in mind are the following:—

Protoxide or manganous oxide . . .	MnO.
Sesquioxide or manganic oxide . . .	Mn_2O_3.
Peroxide or black oxide	MnO_2.
Manganoso-manganic oxide or red oxide . .	MnO,Mn_2O_3.

In estimating the quantity of manganese in any particular ore, it is usual to convert it into the last-named, or red oxide. If no other metals are present in the specimen the process is a simple one. After being weighed, it is first dissolved up and then boiled, after which an excess of carbonate of soda is added which will cause the whole of the manganese in the solution to be precipitated as a carbonate. This is collected on a filter, well washed with boiling water, and lastly ignited in a crucible until it no longer decreases in weight. The result will be the red oxide, a comparison of which with the original weight of the article operated upon will give the per-centage of manganese in the ore, the atomic weight of the metal being 55.

Another method very commonly adopted in valuing the ore consists in weighing out a certain quantity of it, and then treating it with hydrochloric acid, by which means it is converted into chloride of manganese, water, and free chlorine. The especial significance of this mode of dealing with it will become more apparent when we come to speak of the chief use of this substance in the arts—the manufacture of bleaching-powder. The chlorine gas is absorbed as fast as it is generated by passing it into a solution of potash. A test solution of arsenious acid is then made of a known strength, and this is coloured blue with a little indigo, and put into a graduated tube. The blue liquid is then poured very gradually into the potash solution, which deprives the indigo of its colour as long as there is any chlorine available. The moment that the indigo is seen to retain its colour it is known that the arsenious acid has exhausted the supply of free chlorine, by their conversion into arsenic and hydrochloric acids; and the quantity of the original acid solution being read off on the graduated tube, it is easy to calculate the amount of chlorine that was originally in the potash solution, two atoms of chlorine being to one of the peroxide of manganese as 71 is to 87, and from that the proportion of manganese in the ore.

Manganese, until a very recent period, was scarcely used except by the glass-maker, who employed it for the purpose of depriving glass of the greenish tint which it nearly always acquires, in a greater or less degree, from the presence of minute quantities of iron in the materials from which the glass is made. This slight colour is the more objectionable now that very thick glass is so largely used, and it is therefore more than ever necessary for this purpose. Of course none but the very purest qualities of ore will suit the glass-makers, and they must be especially cautious that it contains no iron. Wad nearly always

has some of the latter metal associated with it; but pyrolusite may be obtained in some places altogether free from this objectionable ingredient, and it is this description of ore which is therefore almost exclusively used by them.

In making bleaching-powder or chloride of lime, the old plan was to treat with sulphuric acid the oxide of manganese mixed with common salt (the chloride of sodium), in a still made of strong sheet-lead. The accompanying diagram (Fig. 1) will show the arrangements necessary for the purpose. The ingredients are contained in the receptacle A, which is entirely surrounded by an outside shell B, which is dome-shaped above, a sufficient space being left between A and B for steam to pass round. The receptacle is provided with a rotatory stirrer, worked by a rod which passes out through the top of the dome. The manganese ore and the salt are dropped in through the opening C, and the acid is poured in through the twisted funnel D. The steam, which is commonly employed as the source of heat, is introduced at E, the pipe F on the opposite side being merely the channel through which the charge is withdrawn after it is exhausted. All the openings being made quite fast, the steam is turned on, and the temperature kept up at about 180° Fahrenheit, the mixture in A being well stirred until chlorine ceases to be evolved. As the gas is set free it passes off through the pipe G into the receiver, where it is combined with lime in order to make bleaching-powder. The latter part of the process has, however, nothing to do with the subject of the present article.

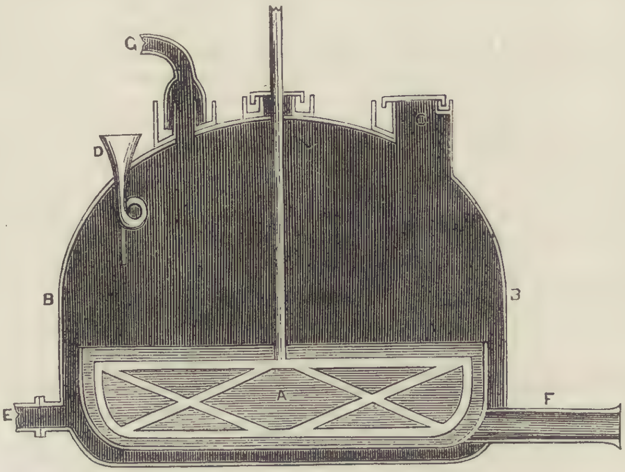


Fig. 1.—STILL USED IN MAKING BLEACHING-POWDER.

A much cheaper mode of producing the chlorine gas required for this purpose is to digest the manganese ore with the waste acid produced in the alkali works by the decomposition of common salt, in the manufacture of sulphate of soda. The chlorine vapours given off in the soda manufacture used to be a source of great annoyance to the neighbourhood, and measures had to be taken to abate the nuisance. The result was that apparatus was designed for the economical condensation of the gases into hydrochloric acid, which is now produced at such a price, that the cost of bleaching-powder has been reduced to about one-third of what it was when salt and sulphuric acid were employed. As already stated, the result of the action of hydrochloric acid upon the manganese ore is to convert the oxide into a chloride, setting free gaseous chlorine at the same time. The theory of the process may be best illustrated by the following equations, which show the proportions of hydrochloric acid to one equivalent of some of the various oxides which may be conveniently used for the purpose:—

Black oxide . $MnO_2 + 4HCl = MnCl_2 + 2H_2O + 2Cl.$
Sesquioxide . $Mn_2O_3 + 6HCl = 2MnCl_2 + 3H_2O + 2Cl.$
Red oxide . $Mn_3O_4 + 8HCl = 3MnCl_2 + 4H_2O + 2Cl.$

It will be seen that the proportion of hydrochloric acid required varies in each case, though the proportion of chlorine evolved is constant, the increase being in the chloride of manganese. This naturally points to the black oxide as the most appropriate for the purpose.

For some years after the introduction of this process on a manufacturing scale, the chloride of manganese was treated as a waste product, and was thrown aside. Various plans have been proposed for utilising this material, and some have been found practically successful. At the great works of the Messrs. Tennant, of Glasgow, the chloride is converted into the carbonate of manganese by heating it under pressure with chalk in an iron boiler, chloride of calcium being formed at the same time; the latter substance is dissolved out, and the carbonate of manganese dried on iron trays, the temperature of which is gradually raised until the carbonic acid is driven off, and the manganese is left behind in the state of peroxide. By this plan the same material can be used over and over again, rendering fresh supplies of the mineral almost unnecessary.

The chloride itself, when properly purified, is used as a brown dye. A neutral solution free from iron may be prepared by digesting the crude article along with powdered chalk, by which means the sesquioxide of iron which is generally present will be decomposed.

The sulphate is, however, more generally used. It is made by roasting the peroxide with a little powdered charcoal, so as to reduce it to the protoxide, MnO; and this is next converted into the sulphate by treating it with dilute sulphuric acid. The iron which is commonly associated with it is got rid of by evaporating down the solution, and then roasting the residue, by which means the iron is converted into an insoluble salt; the pure sulphate of manganese being separated therefrom by dissolving it out with water. On evaporating down the solution the salt will crystallise out. A shorter process is to mix the peroxide of manganese with sulphate of iron, and roast the two together, producing at one operation the sesquisulphate of iron and the sulphate of manganese, which are then separated as before by dissolving out the latter with water.

In dyeing with manganese sulphate, the cloth is first dipped in a solution of this salt for a time, and then treated with an alkali, which combines with the sulphur and leaves the manganese free to take up oxygen. It thus becomes gradually converted into the peroxide, or black oxide, as it is commonly called, but which is really a brown, and appears of that colour when used in small quantities. The raising of it from the protoxide to the peroxide is expedited by afterwards dipping the cloth in a chloride of lime solution.

The acetate of manganese is also used for a similar purpose, and in a similar manner. It is made from the sulphate by adding acetate of lead, in the proportion of seven parts of the latter to four of the former, both salts being first dissolved in water. The colour is brought out by the use of chloride of lime only.

An application of manganese of some considerable importance, both in a social and commercial aspect, is due to the instability of the manganates and permanganates of the alkalis. The solutions of the alkaline permanganates are of a deep purple-red colour. They are all reduced by the action of organic compounds to a colourless state, so that water which is rendered impure by the presence of any nitrogenous substance can be at once tested by dropping it gradually into one of these solutions. On account of their value as oxidising agents, and the rapidity with which they act upon organic matter, they are largely employed as disinfectants in sick chambers, and may also be applied with advantage to putrid sores and wounds, as well as to tainted meat. The permanganate of potassium, which is one of the combinations most usually adopted for such purposes, is made by igniting one volume of peroxide of manganese with one of hydrate of potassium, or 1·8 of nitrate of potassium. The product is then dissolved in water, decanted and evaporated, rapidly at first, until the red crystals of the permanganate begin to appear, and then gradually till the operation is complete.

The value of manganese as an oxidising agent in the manufacture of iron and steel has been described already in detail when treating of those operations, and the reader may be referred to Article XIV. of this series (Vol. III., page 30), where the composition and uses of spiegeleisen and also the alloy called ferro-manganese are fully considered.

OPTICAL INSTRUMENTS.—XXIII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN (*continued*).

The Principles of Lantern Construction.—It will be well at this stage to consider the most important points in lantern construction, according to modern experience. The *body*, made either of metal or wood, is arranged so as to prevent any rays from "the source of light" escaping into the room where the views are exhibited, for any extraneous light would detract from the brilliancy of their colours and sharpness of their outlines, especially if the source of light be a weak one, as in the case of the Argand burner, greater latitude as to this condition being allowable if the lantern is to be employed for the lime-light or electric light only. The body may be square or round, but is usually oblong. The height is governed by the requirements of the source of light, being usually sufficiently high to allow the chimney of an Argand lamp, or the upper pole of an electric regulator, to stand beneath the *dome* or roof of the lantern, though if the oxy-hydrogen light only is required, then the body may be very squat, especially if portability be a matter for consideration. The *chimney*, employed for the double purpose of carrying off the smoke of a lamp and creating an "up-draught" for ventilation, must be placed immediately over, and central with, the chimney of any lamp when it is placed in focus with the condenser. The chimney as usually constructed is of the form shown in Fig. 105; but I consider its contracted shape very objectionable, as interfering with free ventilation. The cylindrical chimney employed in the old-fashioned lanterns, and modern instruments of large size, shown in Fig. 106, also hampers ventilation by the contracted nature of the gauffered cowl. A better arrangement, I found, was to make the chimney cylindrical, and of the form shown in Fig. 107, of equal diameter throughout its entire length. At first, for the purpose of cutting off the small amount of light reflected from the dead black surface of the inside of the chimney, I introduced two semi-circular diaphragms fixed as shown at D, D; but I found it better to dispense with these, so as to give an unimpeded current to secure perfect ventilation. Since then I have made the chimney on this principle, but square (Fig. 108), instead of cylindrical, for the purpose of economising space, by utilising the inside of the chimney for holding slides, in the manner hereafter to be described. The *floor* of the lantern is usually double, and pierced with a double series of non-corresponding air-holes on each side; but I found it advantageous to provide for a greater amount of air passing through the body of the lantern, either by large openings in the base of the lantern, or by slots an inch wide running along each side of the floor, when the body was made in wood. By thus introducing a larger and freer current of air through the lantern, I found that the tin linings usually added to the better class of bodies for the purpose of keeping the exterior wall cool to the touch, were quite unnecessary, as I could keep my hand on the top of a lantern made of a single thickness of tin, even after a powerful Argand lamp had been burning in it for some time, the metal being kept perfectly cool by the increased draughtway. The lamp is usually supported in a socket, A, and the lime-light jets on a slight rod B, fixed to a tin tray that slides into grooves in the floor of the body, as shown in Fig. 109. I prefer, however, to make the base of the lantern in wood, to allow of a solid mahogany slab, sliding in and out freely by groove-and-tongue fitting, being employed to carry the brass rod on which the lamp or jet is adjusted for focussing the light with the condenser, as shown in Fig. 110. Most lantern-workers must have experienced the difficulty of firmly clamping any form of burner or jet that has, through its length, much leverage, on to the thin adjusting rods usually attached to the lamp-trays. To overcome this, I tried larger rods and powerful screw-ring clamps, but with slight advantage, when I thought of filing away the side of the supporting rod R, opposite the thumb-screw, S, so that two sharp edges were left to bite on the adjusting clamp-tube, T, as shown in Fig. 111, and the defect was perfectly mastered. The clamp-ring attached to each form of lamp should have the inner lining tube projecting upwards to such a height that it can carry the reflector, so that lamp and reflector may be adjusted at the same time, as in Fig. 90, page 365, Vol. III. The adaptation of the kaleidoscope to the lantern renders an adjustment for the lamp as well as the jets imperative.

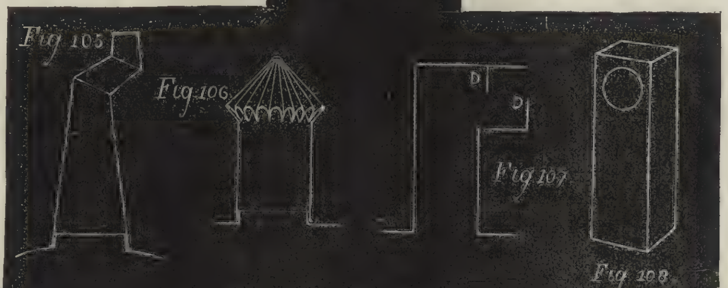


Fig. 110.

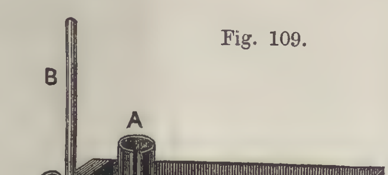
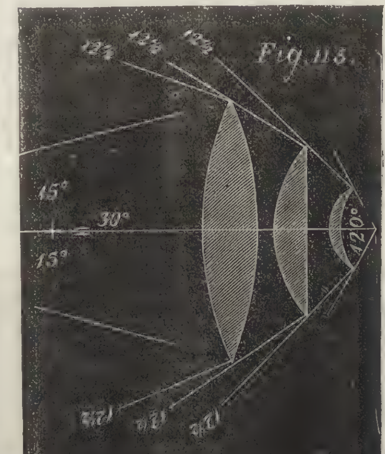


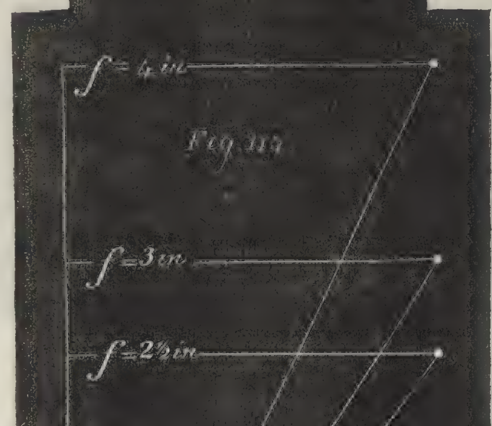
Fig. 109.

The *sources of light* for the magic lantern have been fully described in the previous series of articles on "Optical Instruments" in Vol. III. of THE TECHNICAL EDUCATOR.

The *reflector* used in conjunction with lamps is usually made of plated copper; but as the plated surface readily tarnishes, and soon gets scratched with cleaning, I find it is preferable to employ concave glasses backed with pure silver deposited by Liebig's or Petitjean's processes, protected by a stout covering of electro-deposited copper, and supported by light metal arms fitted to an adjusting screw, in the manner

previously described (Fig. 90, page 365, Vol. III.). Such glass reflectors only require wiping just before use, and always retain a brilliant reflecting surface. Plated mirrors have been found to absorb half of the light they receive: such mirrors as I recommend reflect about 90 per cent. of the incident rays; while glasses backed with mercury reflect only about 65 per cent., and these are at least 20 per cent. better as to reflecting power than plated copper when new. The reflector must not subtend a greater angle from the centre of the flame than does the first lens of the condenser, or the rays from its margin would fall outside the edges of the lens. The best effect is attained when both subtend exactly the same angle, and the centre of the flame F coincides with the centre of curvature of both the reflector R and the lens L, as shown in Fig. 112, in which case both R and L should also be of the same diameter. As a rule, sufficient attention is not given to the form and focal length of the concave reflector in its relation to the condensing lens, and no provision is made for its proper adjustment; hence it often mars rather than adds to the even brilliancy of the field on the screen. In such instances a better effect would be produced by simply placing a disc of white paper or a flat white Dutch tile behind the flame, or, better still, a flat reflector made out of baked pipe-clay.





The *condenser* may be single, double, or triple, and its construction is framed with the view of picking up the greatest number of rays from the source of light, compatible with obtaining a flat field, free from all colour except at the extreme margin of the disc, when projected on a white screen in combination with a "power" of suitable focus. The latter proviso is very necessary, as a condenser with a short focus that may yield a most satisfactory result *per se*, or with a power of short focal length—say of 4½ inches—or of moderate focal length—say of 9 inches—may produce a dark spot in the centre of the field, if employed with a power of long focus—say of 16 inches. It is true we may lengthen the cone of rays by pushing the light nearer to the condenser, but then the cone becomes truncated, and does not come to an apex. A better result will be obtained by using a condenser of a focal length sufficiently long to suit the long focus of the "power."

The condensers in ordinary use are, the common "bull's-eye" or plano-convex, A (Fig. 113), the best position for which is with the plane face next to the light, while the usual focal length adopted is about 2½ inches. The double convex, B (Fig. 113), of about 2½ to 3 inches focal length, from 1½ up to 3 inches diameter, is used with small lanterns; beyond this size it is necessary to employ what is termed the "double condenser," the two previous forms being designated as "single condensers." The double condenser may be formed of two double-convex lenses of equal curvatures, as in C (Fig. 113), giving a combined focus of about 2½ inches focus, each element being of 5 inches focal length. This type may be varied by one lens being thinner, and consequently of greater focal length than the other, or both elements may be "crossed lenses:" in any case it is well suited for Argand burners with large flames, but not for points of light, as when the lime-light or electric light is to be employed; further, this combination is not efficient if over 3½ inches diameter. For flame or point of light a pair of meniscus lenses are used by some makers, as shown in D (Fig. 113), but a pair of plano-convex lenses, shown at E (Fig. 113), form a better and cheaper arrangement, that gives a very flat field. Perhaps the best form of double condenser, and one that has been almost universally adopted by the wholesale lantern-makers, is that represented at F (Fig. 113). This consists of a deep meniscus and a double-convex lens, the combined focus being 3½ inches in old forms, or as short as 2¾ inches focal length (measured from the centre of the combination) in condensers of recent manufacture. This ought to be known as "Herschel's Condenser," having been described by that eminent philosopher in the *Philosophical Transactions of the Royal Society* for 1821, as giving the best curves for crown glass, to correct spherical aberration only, aberration of colour being left uncorrected, as the combination was only intended to act as a very powerful burning glass, for which it answered most perfectly. Its proper position in relation to the source of light is shown in F (Fig. 113), but some lantern-makers mount this combination in a reversed position, through a want of optical knowledge of the aims of the arrangement, and a desire to send out "something different" in aspect from that supplied by their brother makers. I have seen this form designated in some catalogues of the optical dealers as "achromatic condensers," the very point of construction Sir John Herschel ignored. This form, as stated above, is now made of as short a "back focus" (that is, the distance at which parallel rays are brought to a focus, measuring from the edge of the meniscus lens) as 2½ inches; and G (Fig. 113), Gravett's condenser, is of a similar character, for it is a matter of the utmost importance to adopt such an arrangement as will pick up the greatest amount of light, as a condenser simply plays the part of a light-collector. Now it will be seen by the diagram shown in Fig. 114, that three condensers of *equal diameter*, say 4 inches, but of *different focal lengths*, say of 2½, 3, and 4 inches respectively, subtend from the point of light, L, the angles 76°, 66°, and 50°; consequently the condenser of 3 inches focus picks up 10° less light than one of 2½ inches focus, one of 4 inches focus 16° less light than a condenser of 3 inches focus, and 26° less light than one of 2½ inches focus: therefore, the shorter we can make the focus, the nearer we can get to the light, consequently the more light we should pick up, were we not limited by practical difficulties, such as the probable cracking of the lens when placed too close to an intense light, or the jet of ignited oxy-hydrogen gases being reflected backwards on to the lens if the lime-ball pits or cracks through being of inferior quality; which difficulties, to a certain extent, might probably be overcome by placing a plate of plane plate-glass between the light and condenser, and so arranged in the body of the lantern

that an up-draught of cool air should pass between the plate and condensing lens, so that if any breakage occurred it should be with the comparatively valueless plate of glass. Important as it is to seize upon all rays practically attainable when dealing with the lime-light, it is of still greater consideration when arranging the lantern for a weak source of light, such as the most powerful Argand must really be considered. Theoretically, it has been argued that nearly all the light given off from an Argand burner should be collected if placed in the centre of a globe, one hemisphere of which should consist of a reflector, the other hemisphere of a condensing lens or lenses. Though there is no difficulty in making a hemispherical reflector, there would be a great, if not an insurmountable difficulty, in constructing a hemispherical condenser that should be free from spherical aberration, and bring all the rays to a single focal point. In a little work on "The Magic Lantern," by Professor C. Tomlinson, of King's College, London, a lantern with a triple condenser is described, in connection with which it is stated (page 15): "Now supposing the first lens to subtend from the lamp an angle of 120°, it will intercept one-fourth of the whole light.* Each lens may bend the extreme rays which fall on its edges to 25°, so that the bending by all the three lenses may amount to 75°, thus converting the rays from diverging at 60° from the axis to converging 15° towards the axis, so that the extreme rays, after crossing in the centre of the smallest lens or object-glass, may diverge again at an angle of 15° from the axis, or 30° from each other." Not knowing of any arrangement that could include so great an angle as 120°, and perform as stated, I wrote to learn the name of the maker of the lantern figured in this work, which was published in 1854. In answer Professor Tomlinson wrote me, "The lantern figured and described in my little book *is a theoretical one*, and I cannot find that the plan has ever been adopted." Fig. 115 shows Tomlinson's triple condenser as described; but it will be seen that the refractive power of the combination is not sufficient to bring the rays parallel, much more to a converging point of 30° towards the axis.

* A circle drawn on any globe with a radius of 60° encloses a fourth part of the surface of that globe.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Galletly, Curator, Industrial Museum, Edinburgh.

IV.—PROGRESS DURING THE EIGHTEENTH CENTURY—KINDS OF WOOL NOW USED.

From the beginning to nearly the close of the eighteenth century home-grown wool continued to be the only kind used in British factories, Spanish wool not being imported for manufacturing purposes before 1791. During that time the woollen trade remained, with the exception of one or two brief intervals, in a healthy state, but it did not make much progress. This is shown by the exports, which, according to M'Culloch, were, for an average of six years ending with 1739, of the annual value of £3,544,160, or only about £540,000 more than they amounted to in 1700. Notwithstanding the slight advance in the quantities of fabrics made, the eighteenth will ever be a remarkable century in the history of the textile industries, because then were invented all those wonderful machines which have since raised them to their present vast and still growing proportions. The first step in advance of the primitive apparatus, previously in use for thousands of years, was the invention of the "fly-shuttle," by Kay, in 1733. By this and other improvements in the loom, he at once doubled the quantity of cloth which a weaver could make in a given time; and these were first adopted by Yorkshire cloth-makers. Five years later came Paul's still more ingenious invention of drawing out cotton by rollers, afterwards adopted and carried out with great success by the energetic Arkwright. In 1764 Hargreaves constructed the "spinning jenny," in which he made a spinning-wheel turn many spindles instead of a single one. Crompton, in 1779, combined the advantages of Paul's rollers and Hargreaves' spinning frame into a single machine, which has since been called the "mule." During the seven years between 1785 and 1792 Cartwright matured his power-loom. Finally, leaving minor improvements out of account, Jacquard produced, in 1790, his celebrated apparatus, named after him, for weaving figured fabrics, which practically leaves the designer unlimited in his choice of pattern on the score of cost.

Many naturalists consider that the sheep is more readily affected by changes in the condition of life than any other domestic animal. Wools greatly differing in their properties are, at all events, obtained from different breeds of sheep, and these are "indigenous to the soil, climate, and locality in which they graze." So thoroughly indeed are the several races adapted to a special set of conditions, "that a flock of heavy Lincolnshire and light Norfolk sheep which had been bred together in a large sheep-walk, part of which was low, rich, and moist, and another high and dry, when turned out regularly separated from each other." Sheep from a tropical climate, when brought to England, rarely live longer than two years, and when European breeds are sent to the tropics their fleeces quickly change their character, becoming coarse and hairy. Even in its native country the fine wool of the Merino sheep is said to be hard and coarse in the warm season after shearing time, and only to recover its soft quality when cold weather returns. The Down wools of England are much softer and cleaner on the rich clay districts of Kent and Sussex than on the sands of Norfolk or the chalk hills of Wiltshire, where they are somewhat harsh in the fibre.

As has been stated in an earlier paper, wools for commercial purposes are divided into *short-stapled* or *carding wools* used for woollen cloths, and *long-stapled* or *combing wools* used for worsted stuffs.

The British breeds of sheep yield wools which are classed indeed as long and short, or long and medium, but all, except a portion of the shorter kinds, are used for combing purposes. They are conveniently divided into two general classes:—

I. The *long-stapled wools*, which include the following:—(1) The *Lincoln*, obtained from what Youatt thinks may be considered the parent of the English long-woolled breeds, and which is, at least, a good type of our deep-grown wools; it has a long, bright, silky staple, which makes it well suited for lustre goods, in imitation of mohair and alpaca textiles; the value of this wool has much increased of late years. (2) The *Romney Marsh* wool, also obtained from an ancient breed; like the Lincoln, it is somewhat coarse, but long, lustrous, and adapted for the same kind of goods. (3) The *Leicester* wool, which is now much better than that obtained in former years; although finer than the Lincoln in the staple, it is not so soft and silky, yet still highly esteemed for combing purposes. (4) The *Cotswold* wool, which resembles the Leicester, but rather harsher: not much Cotswold is now obtained, as the pure breed has become scarce. (5) The *Highland* or *Black-faced* breed yields what is rather a wool of middle length than long, yet it is usually classed with the long-stapled wools. In quality it varies much, according to the care bestowed upon it; but its general use is confined to rugs, carpets, and Scotch blankets.

II. The *short* or *medium-stapled* wools, which are principally furnished by the different breeds of Downs. These all possess the same general characters, so that any differences which do exist are owing more to soil and climate than to any particular variety of breed. (1) The *South Down* is a short-stapled wool, fine in the hair, but slightly harsh and brittle, of which the longer qualities are combed—*i.e.*, prepared for worsted yarns—and the shorter for making flannels and light woollen goods. (2) The *Hampshire Down* only differs from the last in being usually longer in the staple and somewhat coarser; (3) the *Oxford Down* is still longer and coarser; while (4) the *Norfolk Down*, although often dirty, with sandy particles in certain districts, yields a fine, valuable wool, softer but not so strong as the pure South Down. (5) The *Shropshire Down* has a longer and more lustrous staple than any of the other Down breeds, and is increasing in importance. (6) *Cheviot wool* is derived from a valuable and hardy breed, now very widely diffused over Scotland and many parts of England. It is of medium length, fine-haired, and largely used for both worsted and woollen goods, fine cloths excepted. (7) *Welsh wool* has some of the fine qualities of the South Down, but has a hair-like texture and is deficient in the waved or spiral form, which gives a special value to high-class wools. Much of it is consumed in the manufacture of Welsh flannels and blankets. (8) *Shetland wool* is not unlike the Welsh in most of its properties, only it is much finer and softer. Its exceeding fineness is well seen in the beautifully-knitted shawls, veils, and the like, made by the peasantry of the islands.

For technical purposes fleeces are further divided into two classes, according to their age; thus, the fleeces shorn from sheep which have not previously been shorn as lambs, are

called *hogs* or *tegs*. Such fleeces are, as a rule, longer and more pointed and spiral in their staples than those clipped subsequently from the same sheep. This yearling wool accordingly possesses properties which suit it better for some kinds of goods than that obtained from older animals. Although not strictly adhered to, the term "hog" applies properly to the first shorn fleece of any long-stapled wool, and "teg" to a similar fleece of short-stapled wool. The other class of fleeces comprises those obtained from sheep in their second and subsequent years, called *wethers* or *ewes*. To good, healthy, sound fleeces more than one year old the term "wethers" is generally given; and "ewes" is applied, in the case of long-stapled wools, to the short, tender, inferior fleeces; while in the short-stapled wools it is applied to the shorter grown fleeces. In some districts along the south coast the farmers clip their lambs, in which case the fleece is called *shorn lambs' wool*. There is yet another description of wool known as *skin-wool*, which is obtained from sheep slaughtered for food. As this is obtained at all seasons of the year it varies much in character, even for the same breed of sheep.

Foreign and Colonial Wools.—The short-stapled wools properly so called—that is, those intended for the manufacture of the better qualities of woollen and for some of the finer kinds of worsted cloths—are now all imported, and, moreover, are all obtained from sheep sprung from the Merino stock. This famous breed, which has conferred great wealth on some of our colonies and other countries, as we shall presently see by some statistics, is a native of Spain. The animal is not prepossessing in appearance, being thickly covered with short wool full of yelk, which gathers a dirty crust, and often gives the fleece the appearance of being singed. Youatt, in his exhaustive book on "Sheep," after noticing that the fibre of Merino wool exceeds in fineness and in the number of serrations and curves that from any other sheep in the world, says, "that the excellency of the Merinos consists in the unexampled fineness and felting property of their wool, and in the weight of it yielded by each individual sheep; the closeness of that wool, and the luxuriance of the yelk, which enables them to support extremes of cold and wet quite as well as any other breed; the easiness with which they adapt themselves to every change of climate, and thrive, and retain, with common care, all their fineness of wool under a burning tropical sun and in the frozen regions of the north; an appetite which renders them apparently satisfied with the coarsest food; a quietness and patience, into whatever pasture they are turned, and a gentleness and tractableness not excelled in any other breed."

This statement is not strictly true as regards the effect of climate, because in warm countries like Spain the flocks are believed to preserve the fineness of their fleeces by feeding in the plains in winter and the mountains in summer, a custom which necessitates their wandering hundreds of miles twice in the year. There is, no doubt, even in Spain, a breed of *stationary* or non-migratory Merinos, which are said to yield wool equal in quality to the migratory ones, but they inhabit the pastures of the Guadarrama mountains; and in some countries of the Southern Hemisphere, where sheep of the Merino breed are now so plentiful, the depreciation of the wool caused by the vicissitudes of climate is so well marked that recourse is had to the importation of fresh Merinos from Europe, in order to preserve its quality. Spain, which in the beginning of the century was our great source of fine wool, now exports but little. For the last fifty or sixty years circumstances have not been favourable for the development of her industries; but it is believed that she has still large flocks of her precious Merinos, of which about 10,000,000 were in the country not very many years ago.

With respect to the production of fine wool in other European countries we find that the Merino breed was introduced into Saxony in 1765, where, with unremitting care and attention, they not only became perfectly naturalised, but in the course of years actually produced wool superior to the Spanish. Saxony wool has long been highly esteemed for the finest woollen cloths, for some kinds of ladies' shawls, and for other high-class goods. Silesian wool from Merino breeds is but little inferior to the finest Saxony. In the Austrian Empire, where Merinos were introduced in 1775, the first attempts to produce fine wool were not successful. Ultimately, however—and especially in Bohemia, Moravia, and Hungary—they were attended with complete success, and much of the wool now grown in these provinces is perhaps unrivalled in quality. In several large districts of Austria the cultivation of the sheep forms the chief source of wealth, the total number of all kinds in the country, as estimated a few years ago, being not less than 30,000,000. Russia is known to produce Merino wool little inferior to the best German, but in that vast empire almost every other kind and quality of wool is reared as well. The quantity Russia sends to Great Britain annually has much increased of late years, and in 1870 it reached the large amount of 6,000,000 lbs. This, too, must be a comparatively small portion of its exports, as most of the wool not consumed in Russia itself is sent to France. Russia in Europe contains about 70,000,000 sheep of all kinds, of which about one-fifth part are Merinos. France appears to be paying more attention than formerly to the culture of wool, and especially to Merino of the second quality. It exported 5,689,953 lbs. to Great Britain in 1870, while a few years back it sent none. France has at the present time about 30,000,000 sheep, of which about two-thirds are Merinos, either pure or crossed. Italy and Turkey are both considerable wool-producing countries, and the latter especially in this respect capable of great development.

In no country on the face of the globe has the success attending the introduction of Merino sheep been so absolutely astonishing as in Australia. Three rams and five ewes were taken out to that country in 1797 by Captain M'Arthur, and from these have sprung the vast number of this fine breed—now more than 40,000,000—whose fleeces, as shown in the table in the following page, yield more than one-half of all the wool imported into England. Australian wool is generally of regular fineness, elasticity, and strength. It bleaches pure white, is easily twisted, and will do equally well for carding or combing. The stronger sorts are now much used in England, France, and Germany for the fabrication of merino and other fine tissues for female wear; while the feebler kinds are used for carding purposes, in which case the felting process gives the cloths into which they are made sufficient strength. Next to Australia in importance, so far as British imports are concerned, stands South Africa. This country has made rapid progress of late years, and, like Australia, produces wool not much inferior to the finest German. Indeed, the perfection to which machinery has now been brought enables the manufacturer to produce, with these lower-priced colonial wools, goods which look as well as those made from the choicest German fleeces, except in some special fabrics. The wools of the Cape are less fine, but more soft and tender than those of Australia. They are also shorter in the staple, and therefore are mostly used for carding purposes.

Wool has of late years become an important article of export from India, but the supply appears to be falling off again. Most of it is of inferior quality, although it is stated in an Inland Revenue Report issued a few years ago that some of the valleys through which the tributaries of the Indus flow "supply grazing ground not to be surpassed in richness and suitableness in any part of the world. The population inhabiting them are chiefly pastoral, but, owing to sloth and ignorance, the wool they produce is but small in quantity, full of dirt, and ill-cared for in every way." Merino rams have been imported for the purpose of improving the breed, but not yet with much success. It is in Northern India where the finest wool in the world is obtained. This is the downy wool found next the skin below the thick coat of hair of the Thibetan goat, and from it the fine Cashmere shawls are made. It sells for about seven shillings per pound, or nearly double the price of the finest German wool.

In the region of South America watered by the La Plata and its tributaries, the increase in the production of fine wool since the first importation of Merinos, in 1826, has been, as in other countries of the Southern Hemisphere, very remarkable; scarcely less so, indeed, than in Australia itself, for the quantity exported from Buenos Ayres in 1866 amounted to 140,000,000 lbs. The wools of the province of that name are fine and soft, but generally wanting in strength, although those of the neighbouring provinces are inferior in quality. None of these wools are so much esteemed in England as they are in France and Belgium. Probably this is mainly due to the fact that they are, like the common wools grown in other parts of South America, much mixed with seeds and burrs, which are difficult to remove. The French, however, think it is partly due to prejudice. We

are indebted to South America for a peculiar kind of wool, furnished by a tribe of animals nearly allied to the camels, but also in some respects like the sheep. The best known of these are the alpaca, llama, vicuna, and guanaco, but only the first two are domesticated. They inhabit the high valleys of the Andes, in Peru, Chili, and Bolivia. The alpaca alone is reared for its wool, which is extremely fine, silky, of various colours, and usually from six to twelve inches long, but occasionally much longer. The llama, though mainly of service as a beast of burden, also yields wool, which, however, is coarse; while that obtained from the vicuna is much prized for its fineness. It is only about forty years since the wool of the alpaca tribe became an article of commerce, and in 1865 the imports had reached 3,000,000 lbs.; in 1870 they amounted to 3,888,536 lbs. It is said that European sheep are now displacing the alpaca and llama in the Peru-Bolivian Andes, the ass taking the place of the latter as a beast of burden.

The following table shows the imports of wool into Great Britain for the last sixty years, from which the reader will see the remarkable changes which have taken place in the sources of supply.

IMPORTS OF WOOL INTO GREAT BRITAIN FROM THE CHIEF WOOL-PRODUCING COUNTRIES.

Yr.	Spain.	Germany.	Australia.	South Africa.	East Indies.	South America.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1810	5,952,407	778,835	167	......	......	Trifling before1833.
1820	3,536,229	5,113,442	99,415	29,719	......	
1830	1,643,515	26,073,882	1,967,279	33,407	......	
1840	1,266,905	21,812,099	9,721,243	751,741	2,441,370	4,378,274
1850	440,751	9,166,731	39,018,221	5,709,529	3,473,252	5,296,648
1855	68,000	6,128,000	49,142,000	11,075,000	14,283,000	7,106,000
1860	1,000,000	9,292,000	59,166,000	16,574,000	20,214,000	8,950,000
1865	115,000	6,858,000	109,734,000	29,220,000	17,105,000	17,867,000
1870	25,262	4,559,000	175,081,427	32,785,271	11,143,148	12,457,631

It is necessary to state that in the above table alpaca wool is included in the figures under "South America," and that the large imports from Russia and France already given, as well as smaller supplies from other countries, are omitted. The total imports for 1855, 1860, 1865, and 1870 are as under :—

	1855.	1860.	1865.	1870.
	lbs.	lbs.	lbs.	lbs.
Total imports	99,300,000	148,396,000	212,206,000	263,250,499
,, exported ...	29,453,000	30,761,000	82,445,000	99,643,789
Left for consumption	69,847,000	117,635,000	129,761,000	163,606,710

To this we require to add the amount produced yearly in Great Britain, for which 160,000,000 lbs. is probably a low estimate, thus raising the quantity annually consumed in our manufactures to nearly 325,000,000 lbs.

But there is something more to take into account. Woollen rags, under the name of "shoddy," are now used to a very large extent in the manufacture of the cheaper kinds of cloth. So also, although the supply is much more limited, is the wool of worn-out fabrics mixed with cotton. In this case the latter material is destroyed by a chemical process, leaving the wool intact, which is then called "extract." Technically speaking, soft woollen rags, as flannels, blankets, and stockings, are converted into "shoddy," and hard and fine woollen rags, including new cloth cuttings, into "mungo." But shoddy, as a general term, includes also mungo and extract. Although it is now about sixty years since the use of shoddy in the manufacture of woollen goods commenced, yet it is not more than half that period since it began to be largely employed. It is now, however, an indispensable material for medium and cheap clothing, second only in importance to wool itself. The amount of "shoddy" imported in 1870 was fully 21,000,000 lbs., and the annual home production was estimated in 1865 to be 52,000,000 lbs. Altogether, the amount of this formerly "waste material" now yearly consumed in our woollen manufactures cannot be less than between eighty and ninety million pounds.

In the *Journal of the Society of Arts* for June 14, 1872, the following table is given, which shows the estimated production of the countries which contributed wool to Europe and America during 1871 :—England, 159,969,000 lbs.; Australia, 152,500,000; Van Diemen's Land, 6,136,000; New Zealand, 28,875,000; Cape of Good Hope, 38,000,000; La Plata, 138,070,000; East Indies, 18,797,000; Russia, 90,760,000; Sweden, 6,082,000; Norway, 6,395,000; Greece, 7,618,000; Denmark, 7,034,000; Holland, 6,130,000; Belgium, 3,500,000; Switzerland, 1,336,000; United States, 177,000,000; France, 91,608,000; Spain, 74,433,000; Germany, 52,080,000; Austria, 31,075,000; Italy, 24,840,000. Total, 1,121,519,000 lbs.

Of materials analogous to wool we have already mentioned the down, or "shawl wool" from the Thibetan goat. But so far at least as quantity is concerned, the woolly hair, called *mohair*, which forms the fleece of the Angora goat (*Capra Angorensis*) is of far more importance. This valuable goat inhabits the mountains in the neighbourhood of Angora, in Asia Minor. We formerly noticed the fact that fabrics had been made of mohair in Italy in the fourteenth century, but in modern times and among Western nations, it is only since 1848 that the value of this beautiful textile material has been appreciated. The staple of mohair is from five to six inches long, and hangs in curls. It is much esteemed for its silky appearance and its milky whiteness. At Bradford and Norwich, as also in France and other countries, it is largely made into fabrics for ladies' wear, linings, tabinets, plushes, and velvets; but in most cases it is mixed with other fibres. The hair of the common goat is also used for manufacturing purposes, although the quantity obtained is not large. In 1870 our total imports of goats' hair or wool amounted to 3,078,506 lbs., the larger proportion of which came from Turkey. Camels' hair, which strongly resembles wool, is woven into cloth in Egypt and Turkey, and in Russia strong military clothing is made of it. The hair obtained from the ox, and in small quantities from some fur-yielding animals, also finds several applications in the arts. To the furs used in making special kinds of felted goods we shall refer again.

GREAT MANUFACTURES OF LITTLE THINGS.—XIII.

CABINET BRASS-FOUNDRY.

BY CHARLES HIBBS.

THE reader has but to glance round the apartment in which he happens to be, and notice the different brass articles that he sees attached to the woodwork of the building or the furniture, to know what is meant by cabinet brass-foundry. There are other branches of the industry entirely distinct and separate from this, which we shall not require to go into, such as the manufacture of gas-fittings and gaseliers, tube-drawing, cock-founding, etc. These are mostly carried on as independent trades by manufacturers who produce nothing else; or, where they form part of the production of a large general brass-founding establishment, have separate departments assigned them under separate management. The rolling of sheet brass may be also said to belong to the trade, but as that is generally performed in large metal rolling-mills, which also reduce ingots of copper, German silver, and plated metal to the sheet form, to suit the convenience of a multitude of businesses in which the staple raw material takes this shape, we have nothing to do with that either. In cabinet brass-foundry is comprised all the "little things" which are made of this beautiful and useful metal, such as brass knobs, sash-fasteners, blind-pulleys, bell-pulls, hat-pegs, curtain-rings, letter-clips, cupboard-fastenings and bolts, table and chair castors, stair rods, and an infinite number of miscellaneous and incongruous articles, from heathen idols to brass-headed nails.

Before proceeding to describe the methods by which these articles are produced, it will be proper to advert for a moment to the composition of the metal of which they are made. The brass of modern commerce is of comparatively late introduction; that which is known by the name in ancient sacred and profane records being probably bronze, a mixture of copper and tin. The brass vessels of the Temple, and the brazen pillars and the lavers, and the molten sea, which contained 2,000 baths, and the innumerable utensils which Hiram made for King Solomon, were of this metal. At least it is certain that none of the examples of ancient metallic art that have yet been discovered yield any evidence that zinc, the second ingredient in

the composition of brass, was knowingly made use of. It may have happened that calamine, or *cadmia* as it is called by Pliny, which is the ore of zinc, was found occasionally in such close proximity to the ore of copper as to lead to the accidental fusion of the two metals, such a mixture being probably that alluded to by ancient writers as yellow copper; but the alliance of copper with zinc, now one of the most common processes in metallurgy, seems not to have been thought of as an art until after the Christian era. The Romans had a metal called *orichalcum*, which appears to have closely resembled our brass, and was perhaps composed of the same ingredients, and it was of this that Vitellius caused copies to be made of the ornaments that enriched the temples of the gods, afterwards fraudulently substituting them for the real objects, which were of gold. Brass-working was practised by the Flemish and Germans long before its introduction to this country; and the monumental brasses which adorned our old cathedrals were imported from those countries.

Our forefathers long continued to make brass in a manner which, to our notions, seems strangely cumbrous and slow. Every caster now mixes the metal for himself, it being simply a compound of copper and spelter—*i.e.*, zinc—in proportions determined by the quality of the brass it is intended to produce. The copper is first put into the crucible, and the spelter, broken into small pieces, is dropped in when the copper is in a melted state. But it was formerly considered necessary to smelt together the ores of the two metals, and for this purpose immense furnaces had to be used, and the most elaborate operations carried on. The furnace was in shape somewhat like the dome of a glass-house, and within it were ranged nine great pots of fire-clay, the largest, or *king-pot*, being in the centre. These were charged with calcined calamine and coal mixed intimately together, having been ground fine with water and passed through a sieve, to which was added a certain quantity of bean copper. Plenty of fuel was then distributed about the furnace, and well packed in between the pots, and after the whole mass of ore had been subjected to intense heat for twelve hours, the furnace was re-opened, the contents of the pots well stirred, and the mixing rendered complete by pouring the metal from the smaller pots into the king-pot, which was again exposed to heat for a time, and afterwards skimmed for impurities. The great difficulty in this process seems to have been, that the calamine, or ore, would yield metallic zinc in indeterminate quantities, and great experience and caution were necessary to ensure the production of a fixed quality of brass.

The various articles of cabinet brass-foundry are produced in the first place either by casting or stamping. If by the first, they are spoken of as wrought, or solid work. The casting-shop in a well-ordered manufactory stands apart from the other buildings, lighted and well ventilated from the roof, with a tall chimney to carry off the fumes, which are very deleterious, especially if the caster is careless enough to let his pot of metal get over-heated, in which case the spelter flies off in minute flakes and noxious vapour. Too commonly a shop on the ground-floor of a two or three-storey range is made use of, and the suffocating fumes ascend through the floors to the shops above. The furnace need not be large, two pots being sufficient for a caster and his assistant to keep going at one time, their size being about that of a common flower-pot, only longer. These are lifted perpendicularly out of the furnace with a pair of tongs which clip them round, and afford a good leverage for pouring. Round the sides of the shops are wide troughs filled with sand, which, from being turned black by frequent use, looks more like garden mould than anything else. Good casting sand has its value; and when the ground is turned over for building operations in the neighbourhood of a town where metal industries are carried on, the discovery of a bed of sand is often productive of as much profit to the owner as the finding of a seam of coal. The brass caster makes use of moulds of an oblong square form, composed of two stout rims of iron, with front and back boards, and wooden screw-clamps to hold the whole firmly together. Filling one half of this box with sand, which he kneads down tightly with his hands and strikes off level with a straight-edge, he presses the patterns down upon it, placing them flatwise or sidewise according to their shape, and half buries them in the compact bed. He then shakes dry dust over the surface from a bag, and fitting the other half of the box on the top he fills that with sand also, pressing it well down, and stamping on it with his feet. The top board is then laid on, the mould turned deftly over, and the first half lifted off, when the sand will part cleanly in the middle, leaving the patterns behind in their second bed. They are now carefully picked out one by one, so that the mould when put together contains a perfect print of each of them. But before the two halves of the mould are joined, the caster has to make channels for the metal from the pouring holes in the iron rim to the prints, by scooping out little gutters in the sand, connecting two or more prints where necessary in the same manner. In the case of hollow castings, he has also to place the cores, a very delicate process, sometimes requiring great care and dexterity of hand. A little explanation is here necessary as to the construction of the patterns and cores. The patterns for small articles are perhaps first of all roughly shaped in wood, and a casting then taken in lead, which is trimmed down nearer to the final size and fashion. A second casting in brass enables the pattern-maker to produce a perfect model by filing, turning, or otherwise shaping it, as required. Should an ornamental raised design be intended to appear upon the article, it must be now modelled upon the pattern in wax, and a third casting taken, which must be cleanly finished and chased up. The pattern-maker, to say nothing of the taste he may be called upon to exhibit, should be a man of considerable mechanical knowledge and skill. He must know exactly how to adapt his article to the purposes for which it is wanted, and he must also know how far he may presume upon the resources of the caster's art. He must not make a pattern that it is impossible to cast, and especially he must take care that, however intricate it may be, its sides and angles must be so inclined as to leave the sand. If it is to be a hollow casting, the pattern must not be made hollow, but, on the contrary, must have projections upon it, in addition to being solid throughout. Thus, if the article to be cast be of hollow cylindrical shape, the pattern-maker will construct a core mould or box, the matrix in which will be a correct copy of the interior shape of the cylinder, with elongations at the two ends. This box dividing into two halves, enables the caster to obtain a reverse model of the interior in moistened and compressed sand. He will lay this in his mould after the pattern has been taken out, and the metal will run round it, filling up the space between that and the outer print. The pattern-maker has therefore to leave on his first model projections corresponding to the elongated ends of the core, so that they may leave a print in the caster's mould, and enable him to lay the core exactly in its proper place. Allowance must be made at each step of the process for the shrinkage of the metal while cooling, so that the final pattern may be just sufficiently larger than the article to be cast from it. Should there be deep indentations or under-cuttings in the pattern, which would tear away part of the mould on being lifted out, the caster has to resort to a process called false coring, which is the most difficult of all his operations. He first fills these interstices with moistened sand, which he well dries and smooths off, and thus produces an artificial surface, capable of leaving the mould easily. When he has procured a good print from the pattern so metamorphosed, he picks out the cores carefully from the pattern without breaking them, and builds them up in the mould in their proper places, the greatest nicety being requisite, until the matrix is complete. The whole of the moulding frames having been prepared for the entrance of the metal, and screwed up tightly, are ranged along the shop in an upright position, mouths uppermost, and the caster, tying a handkerchief over his mouth to guard against the fumes, lifts the pot from its fiery bed, and quickly goes down the row, pouring a little of the molten metal into each hole until it comes gurgling up to the top, emitting a whitish-blue flame with sulphurous vapour. A few minutes suffices for the operation, and the metal, which is of a dull coppery red when melted, sets immediately, so that no time need be lost in breaking up the moulds. Each in turn is lifted into the trough, unscrewed, and the contents, sand and castings together, tumbled out in a heap. Some will be found to be imperfect, the metal not having reached the extremities of the print, while some will be damaged from the sand having broken down, but the majority, in the hands of a good workman, will be clean sound castings, beautiful in their newness, and perfect copies of the patterns. When cooled sufficiently, they are picked out from the still smoking heap of mould, beaten to free them from adhering particles, and broken off from the

"gets," which are the thin strips of metal filling the connecting gutters. It may happen that these "gets" have absorbed as much weight of metal as the castings themselves, especially if there has been a run on small articles for that pouring, these being treated in a peculiar way by the pattern-maker. To mould each one separately would give the caster endless trouble, so the pattern-maker connects a number of them in a "spray," *i.e.*, a central stem, with branches springing out on either side, and at the end of each branch a pattern of the article. A quantity can thus be moulded at one operation, effecting a great saving of time, though there is the drawback of a great part of the metal being necessarily run to waste, the gets and sprays having all to be re-melted when their purpose has been served. The making of these sprays does not involve so much labour as might appear. The pattern-maker will in the first instance make but one pattern of the article, and the caster sticking this occasionally in an odd corner of his mould, will get from it a number of duplicates in due time. Being trimmed up, these will do duty as patterns, and the caster, moulding them in two rows, will connect them in spray fashion by scooping out channels in the sand. From the rough casting thus obtained a final and perfect spray pattern can be made. But little now remains to be described in the casting process. The cores, which are by this time baked hard, have to be picked out of the hollows, the sand brushed out of the bends and corners, and the castings are ready for the warehouse. An allowance of 5 or 6 lbs. per hundredweight is made for waste, as at each re-melting some part of the volatile zinc will fly off, especially when the metal has to be heated to a high degree to produce castings of a fine and intricate pattern. The extreme delicacy of detail obtained sometimes is really surprising. The writer has seen a sprig of double parsley reproduced in cast metal, all the feathery lightness of the original preserved, and the parts not disarranged in the slightest degree. Within the last two or three years a beautiful method of obtaining highly finished castings has been introduced from America. The mould is made of the finest sand, faced with wood charcoal reduced to an impalpable powder. It is forced by extreme pressure to take every line of the pattern, and the hot metal is also mechanically compressed into all the delicate markings of the mould. Castings from chased and engraved surfaces are thus produced which are scarcely to be distinguished from the originals.

The second method of giving initial form and shape to brass articles is by stamping. Rolled sheet, and not ingot brass, is the material now used, and the metal being laid upon a die, is forced to take its shape by repeated blows. It resembles, therefore, beaten or *repoussé* work, when finished, the contour of the relievo being followed in the depressions of the under side. Much saving of weight is thus effected, and brass becomes applicable to a variety of ornamental purposes in which lightness is a desideratum. The introduction of stamped brass-foundry created a new era in the trade. A writer of the time, speaking of it, said:—"The old process of casting is utterly laid aside, and a more cheap and expeditious method is substituted. Artists of inventive minds and unwearied application have called in the use of dies, presses, and stamps; and one man can, in the same space of time, produce what, on the old principle, would have required ten to perform, and by this improvement beauty and elegance may be obtained without incurring the enormous expense which has hitherto accompanied them." Although it is quite true that by this means forms of lightness and beauty can be produced at less expense, it will be long before the "old process of casting" is superseded by the stamp and die. The early stampers were timid, and used only shallow dies, not knowing the extent to which the ductility of the metal would allow them to punch and torture it into shape, but now there is scarcely any degree of relief that cannot be obtained. The die itself we need not describe; the mechanical reader will know that it is a block of steel welded in a larger block of iron, the impression of the intended work cut in its face. This block the stamper lays upon the stamp-bed, immediately under the descending hammer, and fixes it there by tightening up four strong screws, which surround it horizontally. He has now to consider how many rests the metal will require before it can be forced into all the depressions of the die. If the pattern be sharp and deep, it will require a good many, being re-annealed each time. The stamper perhaps first begins by half filling his die with clay, plastering up all the sharp indentations; he will then take a cast of the hole with melted lead, having first surrounded it with rolls of clay to prevent the metal from running over. When cold, he lets the stamp-hammer down sharply, which being furnished with roughened studs upon its under side, lays hold of the lead "force" and picks it up when re-lifted. This shapeless lump, which resembles the face of a statue when the features have been all worn away and obliterated by age, is now made to descend upon the thin metal, and gives it the first rudiment of the form it is ultimately to assume. Successive operations of the same kind bring it up gradually nearer and nearer to a finish, and the final strokes are given by a "force" cast in brass or some harder alloy in the clean die. Repeated annealings prevent the metal cracking or "flying" in the process, and the acme of art consists in producing a stamping unbroken in any part, and yet reaching the utmost limit of tenuity that the metal can be made to bear.

Formerly, stamping was a most laborious process, the ram or head of the stamp being necessarily heavy, sometimes a hundredweight or more. Where steam-power is used upon the premises, however, a great assistance can be given to the workmen by the simple expedient of passing the rope over a pulley which is connected with the shafting of the machinery. This pulley being constantly revolving at moderate speed, it is sufficient merely to tighten the rope upon it, and it will pull up the weight without much manual effort being exercised. The aid of two "pullers" used to be required for the heavier kinds of work, but now a man of moderate strength can work the most powerful stamp unaided.

A glance at the pattern-books of a large manufactory would show how enormous must be the number of dies which pass through the hands of the managers in the course of a year. The variety seems to be inexhaustible. Not only does every day bring up a call for something never made before, but every staple article has been subjected to innumerable mutations from the changes of fashion, while some have gone out of sale altogether. The dies for the stamper, and the patterns for the caster—both of which are in many cases most expensively got up—form no small part of the fixed capital of the manufacturer. The effect is to operate detrimentally to the progress of pure taste, on account of which a great deal of undeserved obloquy has been cast upon the trade. Some of the leading manufacturers are men of cultivated minds, who are as desirous of improving the style of their work as any art-critic could possibly wish them to be; but in order to keep a balance on the right side of the ledger, they are compelled often to pander to the depraved appetites of purchasers, and are always timid at departing from the beaten track. Novelty is of course sought after, but it must be novelty within the limits of certain styles which the public may be trusted to buy, and vicious ornamentation is unfortunately more the rule than the exception. A die that costs several pounds will be worth only a few pence when its design has ceased to be popular, and in addition there is the contingency of having a large quantity of finished articles lying as dead stock in the market. When it is considered how many hands these pass through in the course of distribution, and that each person concerned has a deep interest in keeping on the safe side, and not trying hazardous experiments on the public taste, it will be seen how narrow is the field for the display of real artistic fancy. A revolution is in progress, nevertheless, but it must come from the outside: it must depend upon the gradual improvement of those who buy and use the products, and it must necessarily be slow.

We have now brought our notice of brass-working up to the point at which the roughly-shaped articles pass into the finishing shops, where they are subjected to the interesting processes which render them presentable for the market. At that point we must leave them for the present.

THE LATHE.—XIII.

By Henry Northcott.

SELF-ACTING LATHES.

The slide-rest or sliding tool-holder would not be of much use for such work as described in the last article, as for most of the work hand-tools would be both more convenient and much more expeditious. The ruler, however, may be to some extent an

exception, as for finishing this the slide-rest would have an advantage over the hand-tool, inasmuch as it would, if properly adjusted and manipulated, leave the ruler parallel, whereas to finish a ruler by hand-tools requires a good deal of care and trouble. If a slide-rest be used, a very slight scraping only should be left for the finishing cut, and this should be taken with a carefully sharpened tool. For this work the lathe requires to rotate at a high speed, and the slide-rest is actuated by hand. The winch-handle may be continuously worked without producing too coarse a traverse. Some modes of rendering the slide-rest self-acting have been already described in connection with simple hand-turning lathes, to which these motions are usually applied; but it is not surprising that when a great deal of parallel work was required, the mechanic should have looked about to see if some simpler and more convenient mode of actuating a sliding tool could not be devised. One very apparent means was that of substituting two spur-wheels for the carrier and stud-wheel shown at Fig. 23 (Vol. III., p. 257). This would give a continuous movement to the tool; but unless the pitch of the traverse-screw of the rest were made very fine it would be necessary to use a very small pinion for the work, and a very large wheel for the screw, in order that the cut of the tool might not be too coarse. Again, as the teeth of the wheels could not be made very long, this connection was rather an inconvenient one, excepting to those slide-rests which allowed the tool to be moved towards or from the work without moving the traverse-slide. Some slide-rests were arranged so as to be driven by a cord or band from an overhead shaft, and passing over two small stepped pulleys. This plan was somewhat more convenient, as it did not interfere much with the movement of the rest; and the stepped pulley could be placed upon either of the slide-rest screws, so as to produce a cylinder or a surface. The pulleys being stepped, also enabled the speed of the traverse or thickness of the cut to be varied for different materials, or when required. But the greatest improvement was effected by converting the lathe-bed itself into a slide, and arranging mechanism to the lathe for moving the slide-rest bodily along the slide thus formed. Lathes of this class are termed "self-acting lathes," or "screw-cutting lathes," according to the nature of the mechanism employed to move the slide-rest along. If a screw and set of wheels be employed, the lathe is usually termed a screw-cutting lathe; but if a rack and pinion, or any other means be used, then the lathe would be known as a self-acting lathe. Many lathes are fitted with a rack and pinion, or other mechanism, to render the movement automatic, and also with a screw and change-wheels for screw-cutting. These lathes are termed self-acting and screw-cutting lathes; and the reason that two sets of mechanism are employed to produce apparently the same kind of motion is that the screw may be reserved for screw-cutting only, as its continual use for ordinary turning soon wears it unequally, and unfits it for accurate screw-cutting.

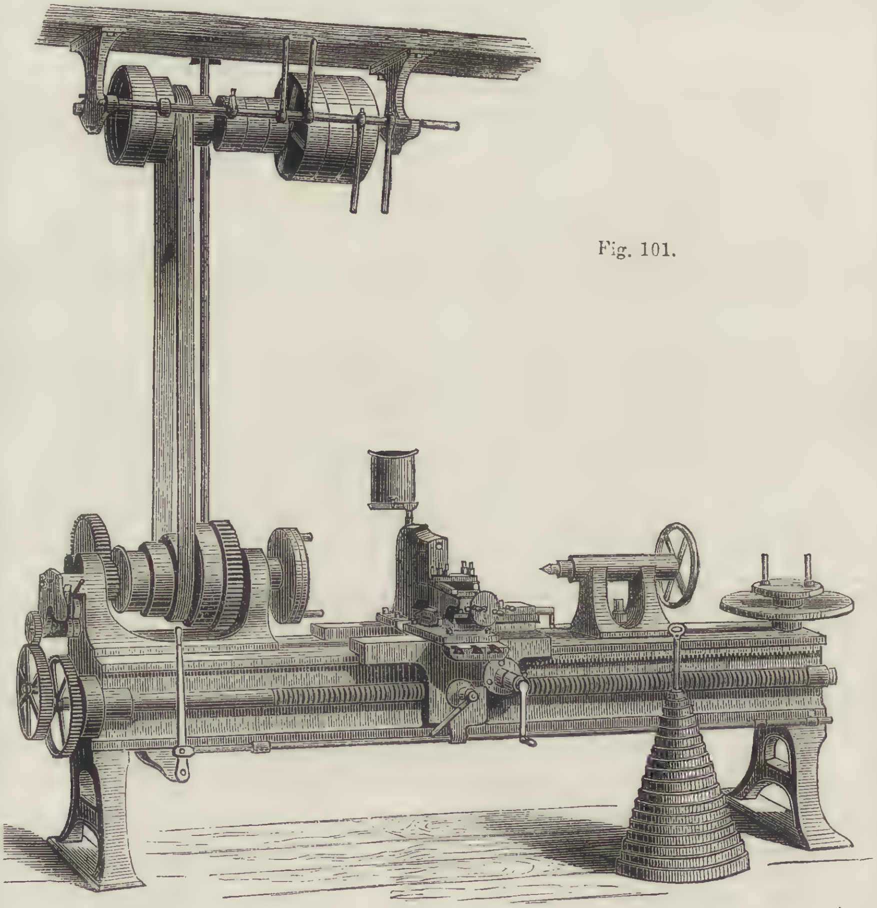


Fig. 101.

Fig. 100 shows a very good self-acting lathe made by Messrs. Fairbairn, Kennedy, and Naylor, of Leeds. This lathe is a good specimen of the class of self-acting lathes in use in large engineering establishments for general work. It is self-acting on both the longitudinal and transverse cuts, so that the mechanism enables both cylinders and surfaces to be produced without any handle-turning on the part of the workman. The lathe has back gearing for the purpose of getting slow speeds and great power, and the general arrangement of the lathe is much the same as of some of those described already; but the proportions are more massive and substantial. The upper part of the bed is flat, as before, but it is carried a little further outwards, and its two edges are formed into a V-shape. The bottom of the slide-rest also is fitted with corresponding V's to embrace and slide along the lathe-bed. This arrangement, as will be seen, converts the whole length of the lathe-bed past the headstock into a slide for the entire slide-rest to travel upon. The lathe-spindle is continued outwards behind, and fitted to receive a three-speeded cone-pulley, and another similar cone-pulley is seen below, with a belt passing over both of them, so that when the lathe-spindle is in motion the lower cone-pulley is also caused to rotate. At the back of the lathe-bed, and out of sight in the illustration, is a long, slender shaft, one end of which is connected with the lower pulley, and driven from it by the spur-wheels seen between the two. These wheels may be thrown into or out of gear at will by means of the small handle at the side, so that the back shaft may be driven or not, as is required. The back shaft carries a sliding worm or tangent-screw, which gears into a suitable worm-wheel, a portion of which only comes into view; and the spindle carrying the worm-wheel is continued across the lathe-bed, through the metal of the slide-rest, and at its front end is furnished with a pinion, connected with the rack by spur-wheels, as shown. The large handle shown in front of the slide-rest is used for moving the rest along the bed to any required position; and such a provision is needed, as the self-acting motion is necessarily very slow.

The lower part of the slide-rest is termed the saddle, and the

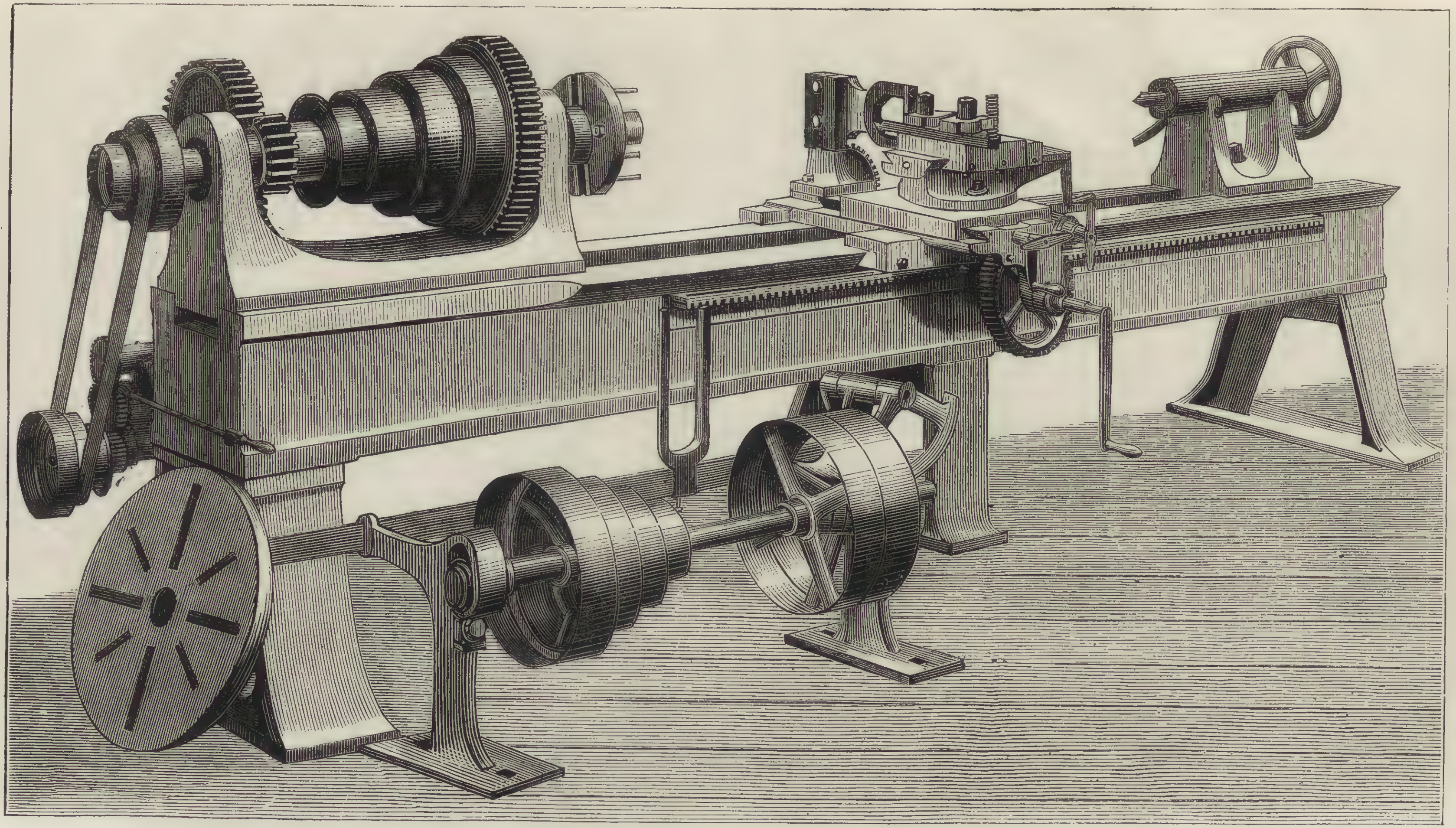


Fig. 100.—SELF-ACTING TURNING-LATHE MADE BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

saddle sliding along the bed of the lathe produces a parallel shaft or cylinder, when the headstocks are properly adjusted. The surfacing-slide is placed exactly at right angles to the lathe-bed slide, so that if the latter by its movement produces a cylinder, the former must necessarily produce a plane surface. Cylindrical shafts and surfaces are almost the only forms the lathe is called upon to turn out; but by altering the position of the line of lathe-centres relatively with the lathe-bed, the traverse-slide may be made to produce tapering shafts, and the surfacing-slide to produce angular instead of plane surfaces. Any small angular parts of the work are turned by the movement of the third or upper slide shown upon the surfacing-slide, and which may be placed at any angle to the work by simply moving a couple of screws; but this third slide must be actuated by hand.

The apparatus at the back of the slide-rest is used as a support for long and slender work, which, without something to hold it in its place, is constantly liable to spring from the tool instead of withstanding its cut. The actual bearing for the work consists of a hard-wood bearing

placed in the jaws of the stay, and it usually follows close behind the tool.

Fig. 101 is a screw-cutting lathe, by Muir, of Manchester. In this example the traverse of the slide-rest is obtained by means of a screw, termed the leading screw, and which is placed along the front of the bed. The screw is driven by means of a series of change-wheels from the end of the lathe-spindle, and the slide-rest is connected to the screw by means of a movable nut, which may be made to clasp the screw and engage with its threads by moving the left-hand handle of the slide-rest. With the lathe in motion, and the change-wheels in place and in gear with the pinion on the end of the spindle, the screw will be rotated at a speed depending upon the size and arrangements of the change-wheels. The slide-rest will, however, only move along the lathe-bed when the clasp-nut attached to the rest is closed upon the screw. The slide-rest of this lathe is made with the two upper slides apart from the saddle, so that the slides may be removed from it, and thus leave the upper surface of the saddle free to receive an engine cylinder or other article to be bored. The illustration shows also the mode in which the lathe is driven from the overhead counter-shaft; but the presence of two sets of idle and driving pulleys may need further explanation.

SEATS OF INDUSTRY.—XXXVI.

NEW ORLEANS.

BY WILLIAM WATT WEBSTER.

New Orleans, the capital of the State of Louisiana, and the commercial metropolis of the southern and western portion of the American Union, extends for about six miles along the left bank of the Mississippi, on a bend of the river shaped like the letter S. The older quarter of the town lying along the outer curve, gave it the name of "The Crescent City." It is situated at a point about 105 miles from the mouth of the Mississippi, about 1,000 miles below the mouth of the Ohio, and about 1,200 miles below the mouth of the Missouri. These rivers and their tributaries give New Orleans steamboat communication with 20,000 miles of river, passing through the richest soils and the pleasantest climates; and it consequently enjoys a greater extent of internal navigation than any other city, either in the Old or in the New World.

The first settlement at New Orleans was formed in 1718, under the direction of Bienville, the Governor of the French province of Louisiana. In 1722 it was spoken of as "the famous town named New Orleans;" but Charlevoix, who visited the place in that year, describes it as consisting of "a hundred cabins, disposed with little regularity, a large wooden warehouse, two or three dwellings that would be no ornaments to a French village, and the half of a sorry storehouse, which they were pleased to lend to the Lord, but of which He had scarcely taken possession when it was proposed to turn Him out to lodge under a tent." Shortly after this date, however, large numbers of French Jesuits and Ursuline nuns took up their abode in the town, and there was then plenty of provision for the teaching of religion; but little was done to develop the commercial resources of the district. In 1763, New Orleans, along with Louisiana, had to be transferred to Spain, about the same time that Canada was taken from the French by England; and it remained in the possession of Spain for upwards of thirty years, when it was restored to the French. In the year 1785 the town contained 4,980 inhabitants; and in 1788 a great fire broke out which destroyed 900 houses, and a vast deal of other property. In 1803, soon after the French had come again into possession of New Orleans, the vast territory of the Mississippi and the Missouri was sold to the United States by Napoleon I. At this date the town contained about 8,000 inhabitants, mostly French and Spanish; and by 1810 the population had more than doubled. The progress of New Orleans after its cession to the United States was exceedingly rapid. Colonisation was then making very rapid progress in the Central and Western States, and for nearly fifty years it seemed as if New Orleans were destined to outstrip New York in the extent of its commerce. It soon became the principal depôt for the cotton and tobacco of the Southern States; and its merchants made great efforts to retain their hold of this trade, by improving the means of river navigation. In 1810 only flat boats, pushed along with poles stuck into the mud, and occupying a hundred and twenty tedious days in the voyage between St. Louis and New Orleans, were to be seen on the Mississippi. The first steamboat that ever plied that river made its appearance in 1815, and accomplished the journey in twenty-five days. By 1860 this distance was traversed in seventy-four hours, by those flying river steamers, which have since become so notorious in America, through the frequency with which they blow up. The population of New Orleans in 1820 numbered 27,176, and by 1830 it had risen to 46,310. In 1817 the exports of cotton amounted to 65,000 bales, and of tobacco to 28,000 hogsheads, besides other produce of various kinds. In 1830, 354,024 bales of cotton were exported from New Orleans; and the imports from the interior in the preceding year included 269,571 bales of cotton, 157,323 barrels of flour, 146,203 pigs of pig-iron, 110,206 kegs of lard, 29,432 hogsheads of tobacco, and 13,472 pieces of bagging.

In 1814-15 the British landed a large force in the neighbourhood of New Orleans, which made an unsuccessful attack on the entrenchments of General Jackson, and had to re-embark, after sustaining very severe losses. Up to the outbreak of the Civil War the prosperity of the city continued to increase with steady and almost unprecedented rapidity. By 1850 the population had risen to 126,375, and by 1860 to 168,823, of whom 13,380 were slaves. In 1848 the exports of cotton from the port of New Orleans amounted to 1,201,897 bales, and of tobacco to 60,364 hogsheads; while a proportionate increase had taken place in the exportation of other important articles of produce, and especially in breadstuffs. Owing to the rapid settlement of the Western States, the progress made in the trade of New Orleans during the succeeding ten years was still more astonishing. The total value of the American produce exported from New Orleans in the year ending June 30, 1858, amounted to 88,270,224 dollars, against 89,039,741 dollars for New York; but the imports into New Orleans only reached a total of 19,586,033 dollars, against 178,475,736 for New York. In 1860, the year before hostilities were actually commenced by the Federals, there cleared the port of New Orleans 958 American and 335 foreign vessels, making a total of 1,293 vessels, with an aggregate burden of 894,353 tons. The total value of the exports for that year amounted to 108,293,567 dollars, and the imports were returned at 22,920,849 dollars. The cotton received at New Orleans from the interior was valued in 1860 at 109,000,000 dollars, and the value of the whole produce brought to the city that year was about 185,000,000 dollars. On the 25th of January, 1861, New Orleans joined in the insurrectionary movement of the "Confederate States," and on the same day the Convention of Louisiana passed an "Ordinance of Secession." For about a year the city remained in the possession of the Confederates. From the 10th of June, 1861, to the 1st of June, 1862, the legitimate trade of the port was suspended by a blockade. Admiral Farragut, in command of a portion of the United States fleet, having previously destroyed the fleet of the insurgents in the Lower Mississippi, and having run past Forts Jackson and St. Philip, suddenly appeared before New Orleans, which surrendered on the 28th of April, 1862, after negotiations that occupied two days. The loss of this city was the first great blow that the Confederates received. In 1861 there cleared the port of New Orleans only 130 vessels, with a total burden of 75,935 tons. Writing before the outbreak of the Civil War, Mr. Flint, in his "Geography and History of the Western States," says: "There have been counted in the harbour of New Orleans 1,500 flat boats at a time. Steamboats are arriving and departing every hour; and it is not uncommon to see fifty of them lying in harbour together. There are often 5,000 or 6,000 boatmen from the upper country here at a time; and we have known thirty vessels advertised together for Liverpool and Havre. The intercourse with Havannah and Vera Cruz is great, and constantly increasing."

Although the blockade of New Orleans was raised in June, 1862, the lower valley of the Mississippi river and its tributaries, the State of Texas and other Southern States which supplied a large portion of its staple exports, and received a large quantity of its imports, were closed to commerce till 1865, and it was accordingly only after that date that the trade of the city began to resume its normal condition. In the year 1864-65, the total quantity of cotton received at the port of New Orleans only amounted to 271,015 bales, but it was sold at an average price of 69¼ cents. In the following year the cotton

receipts rose to 787,386 bales, which brought an average price of $39\frac{1}{4}$ cents. By 1868-69, the quantity had risen to 841,216, sold at an average price of $25\frac{3}{4}$ cents; by 1869-70, to 1,207,333 bales, at an average of 22 cents; and by 1870-71, to 1,548,136 bales, at an average of $14\frac{3}{4}$ cents. The total receipts of cotton at New Orleans and other delivery ports in 1869-70 exhibited an increase of 43 per cent. on the previous year, and of 80 per cent. on the year 1867-68; and the total receipts for 1870-71 showed an increase of 25 per cent. over those of the preceding year, but owing to the fall in price the larger crop of 1870-71 did not realise within 30,000,000 dollars of the sum obtained for the smaller crop of 1869-70. The receipts of sugar and molasses show a still greater increase, which is largely attributable to wider cultivation, the use of healthier cane-seed, and generally favourable weather. Receipts of tobacco and other produce also show an increase; but in some articles, including wheat, there was a decline in 1870-71, as compared with the preceding year. Summing up the statistics of the trade of New Orleans, in his report to Parliament for 1871, the English Consul says:—"The general result is a marked progress in Southern staples, with the exception of rice, and little or no improvement, if not an actual retrogression, in Western produce; and a glance at the railway map of the United States will show the reason why a large and increasing portion of produce which used to be sent down the Mississippi to be exported from New Orleans, is now sent up, to be forwarded by rail to Philadelphia, Baltimore, and even to New York, and, as a matter of course, imports find their way by the same routes." In another part of his report, Consul de Fonblanque says, in reference to the past history and immediate prospects of the commerce of New Orleans: "The old theory that land carriage cannot compete with water carriage is nowhere more thoroughly exploded than in the United States; and it is, perhaps, over-reliance upon its great river as the sole means of transport that has lost New Orleans a part of her trade. Delay, exposure to the weather, and too much handling of goods, are the evils set down against water carriage. If, as seems probable, a line of railway opening up the State of Texas, and connecting this State (Louisiana) with the Pacific seaboard, be constructed, a great future is in store for the 'Crescent City.'"

But notwithstanding the great increase that has taken place in the trade of New Orleans since the close of the Civil War, there remains a considerable leeway to make up before the old amount of business will be reached. A portion of it has, it is to be feared, been finally diverted into new channels, and can never be resumed. New industries promise in some measure to compensate for this loss, and conspicuous among these is the utilisation of cotton-seed, which has recently been carried on in Louisiana to a large extent, 140,000 bags of cake made from cotton-seed having been exported from New Orleans in 1871, while during the first two months of 1872 no less than 66,000 bags were shipped. The shipping cleared at New Orleans for foreign ports in 1871 consisted of 364 American vessels, aggregating 277,765 tons burden, and with a total crew of 6,147; and 542 foreign vessels, aggregating 336,457 tons, and with a total crew of 9,095. In the same year 1,309 vessels engaged in the coasting trade, aggregating 1,108,668 tons, and with a total crew of 30,118, cleared the port. The British vessels that entered the port of New Orleans in 1871 numbered 271, with a total crew of 4,907. Regarding the enterprise of the merchants of New Orleans, and their mode of transacting their business, a very favourable impression is produced by the following paragraph in Consul de Fonblanque's report, showing the revolution in the manner of conducting operations in cotton, caused by the extension and improvement of telegraphy: "Every merchant of any pretensions has an instrument at his elbow as he sits in his office, by which prices are recorded. At what is nine o'clock a.m. in New Orleans, he knows the quotations made at Liverpool at eleven a.m. He has two other despatches per diem, and he hears from New York every hour." Valuable deposits of salt and sulphur are reported to have been discovered recently within a few miles of New Orleans, which only require the application of capital to yield handsome returns. At the present time New Orleans is the third shipping port in the United States, being inferior only to New York and Boston. It has railway communication to the north, the east, and the west, and a canal system connects it with Lake Pontchartrain. Vessels of the largest burden can navigate the Mississippi for hundreds of miles above New Orleans.

One great drawback to the prosperity of New Orleans is the unhealthiness of its site. It is built on a swamp from two to five feet below the level of the river at high water, and is surrounded by swamps that are even below the level of the river at lower stages. In order to keep out the waters of the Mississippi, a levee or platform, from 5 to 30 feet in height, and extending for about 100 miles along the bank of the river, has been constructed, partly out of deposit swept from the north by the Mississippi. Breaches are occasionally made in this dyke, but they are soon closed. It has been proposed to bring earth from the upper parts of the Mississippi, in order to raise the site above the level of the river at high water, but this great undertaking has always been deferred. As might be expected, yellow fever periodically visits the city, usually between the months of June and September, and this plague has sometimes carried off more than 8,000 of the inhabitants. A great number of the poor fall victims to yellow fever on every visitation, and the rich betake themselves to more healthy spots; but owing to improvements in the drainage of the contiguous swamps, and the substitution of stone for wooden sewers in the city itself, the virulence of this disease has been greatly mitigated within recent years. Owing to the damp nature of the ground, however, the houses in New Orleans have no cellars, and there are no graves in the cemeteries, the coffins with the dead being deposited in tombs or "ovens" erected above the soil. The appearance of the city from a distance is not striking, as there are few steeples to relieve the monotonous flat, and it has few public buildings remarkable either from their beauty or their associations. The cathedral, which has four towers and massive walls, ornamented with statues of saints in niches, is the only public edifice of an imposing character. In proportion to the population there are few churches in New Orleans, and it is not very well provided with schools, reading-rooms, or even with newspapers. It has, however, an unparalleled number of lottery-offices, billiard-rooms, and gambling-houses; and morals are reported to be at a lower ebb in New Orleans than in any other city in the United States. The theatres and hotels are on a gigantic scale. In no city in the world is a greater admixture of races to be seen, or a wider variety of languages, manners, and complexions. About one-half of the fixed population consists of black or coloured persons, including creoles of every shade. The bulk of the white population is of French and Spanish descent, but natives of every State in the Union and of every country in Europe are to be found in the motley community of New Orleans. In the older quarters of the city the houses are lofty structures, built chiefly of brick, and many of them are stuccoed on the outside, and painted white or yellow, besides being ornamented with tasteful cornices and iron balconies. These houses in many respects resemble those to be seen in old French and Spanish towns. Few of the streets in the old part of the city are 40 feet wide, and they are very irregularly laid out. In the new quarters the streets are wider and more regular, and the houses are built in the modern American style. During the hot season the street-doors of many of the houses of New Orleans are left open all day, and mosquito curtains are substituted for doors.

TECHNICAL DRAWING.—XC.

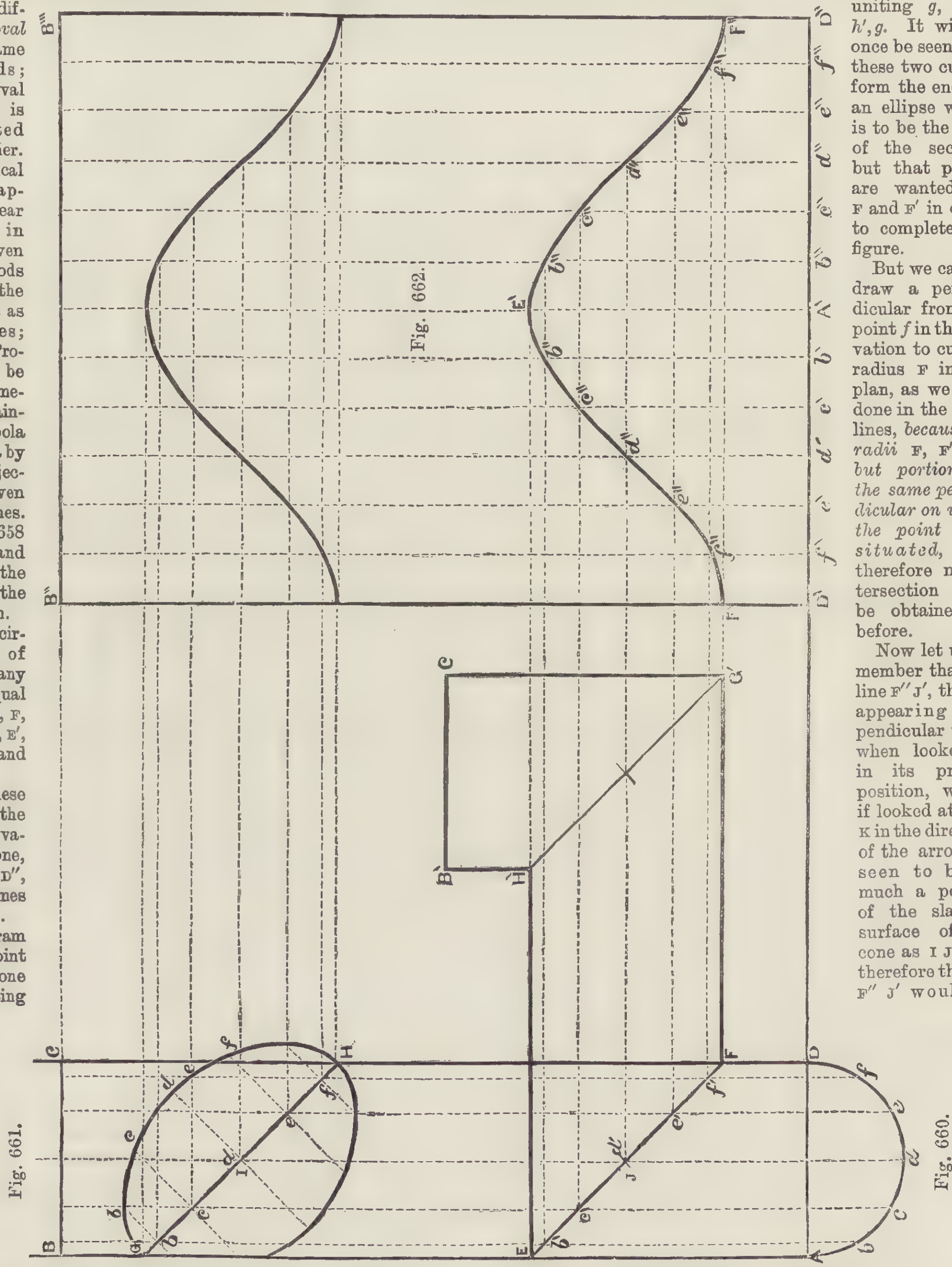
DRAWING FOR METAL-PLATE WORKERS (*continued*).

THE careful student, really desirous of self-improvement, and anxious to gather that store of necessary technical information which can alone ensure his becoming superior to others in the daily practice of his calling, will now be perfectly competent to follow us in this and future lessons that we shall bring under his notice as being specially applicable to metal-plate workers. He has also gained another invaluable piece of knowledge, that bears on the ultimate attainment of success in every position of life, be it what it may, that an intimate acquaintance with the first principles of any branch of learning is the great corner-stone of well-doing and well-being for the future, and that this basis must be carefully built upon by practice and application.

To draw an ellipse which shall be the true section of a cone on a given line.

This lesson is repeated from "Projection," so that by substituting another drawing certain parts may be more especially brought out.

If a cone be cut across so that the plane of section may pass through the axis at an angle and cut the slanting surface of the cone on the opposite sides, the section is called an *ellipse*.



An *ellipse* differs from an *oval* in being the same at both ends; whilst in an oval the one end is more pointed than the other. See "Practical Geometry applied to Linear Drawing," in which are given various methods for describing the conic sections as plane figures; whilst in "Projection" will be found the methods of obtaining the parabola and hyperbola by means of projection from given sections in cones.

Let Fig. 658 be the plan and elevation of the cone, and A B the line of section.

Divide the circumference of the plan into any number of equal parts, C, D, E, F, G, H, I, and D′, E′, F′, G′, H′, I, and draw radii.

Project these points on to the base of the elevation of the cone, and from C″, D″, etc., draw lines to the apex J′.

The diagram up to this point represents a cone on the slanting surface of which straight lines have been drawn, which, on looking down on the apex, would appear as radii of the circle forming the plan.

The line E″ J′ in the elevation is therefore represented by E J in the plan, and thus the plan of any point marked on E″ J′ must fall somewhere on the radius E J.

Now the section line, A B, cuts through all the lines drawn to the apex of the cone in the points *d*, *e*, *f*, *g*, *h*; and it will be remembered that although in the elevation the section is represented by a single line A B, it will assume a different form in the plan. From points A and B draw perpendiculars cutting the diameter C I in *a* and *b*, and from *d*, *e*, *g*, *h* in the elevation draw perpendiculars cutting the radii of the plan which are similarly lettered.

Draw the curve which will unite *e*, *d*, *a*, *d*, *e*, and also the curve uniting *g*, *h*, *b*, *h′*, *g*. It will at once be seen that these two curves form the ends of an ellipse which is to be the plan of the section, but that points are wanted on F and F′ in order to complete the figure.

But we cannot draw a perpendicular from the point *f* in the elevation to cut the radius F in the plan, as we have done in the other lines, *because the radii* F, F′ *are but portions of the same perpendicular on which the point f is situated*, and therefore no intersection could be obtained as before.

Now let us remember that the line F″ J′, though appearing perpendicular to I L when looked at in its present position, would, if looked at from K in the direction of the arrow, be seen to be as much a portion of the slanting surface of the cone as I J′, and therefore the line F″ J′ would be seen to make the same angle with the horizontal plane as I J. If, then, we rotate the cone on its axis, the point *f* will move to *f f*, and a perpendicular drawn from *f f* will give us *f f* in the plan. If, now, we turn back the cone to its original position (which will be represented by drawing a quadrant from the centre of the plan with radius J *f f*), the quadrant will cut the radius F in *f′* and F′ in *f″*. Join *e* and *g*, and *e′* and *g′* by curves passing through *f* and *f′*, which will complete the plan of the section.

This is not, however, the *true section*, but the view when looking down upon it; and as it is slanting, its length from a to b will seem shorter than it really is.

It will be evident that the true length of the section is the line A B. From these points, then, and also from d, e, f, g, h, draw lines at right angles to the section line, and A′ B′ parallel to it. On each side of the points d, e, f, g, h, in the line A B, set off the distances which the points similarly lettered are from C I in the plan, and these will give the points through which the true section may be drawn.

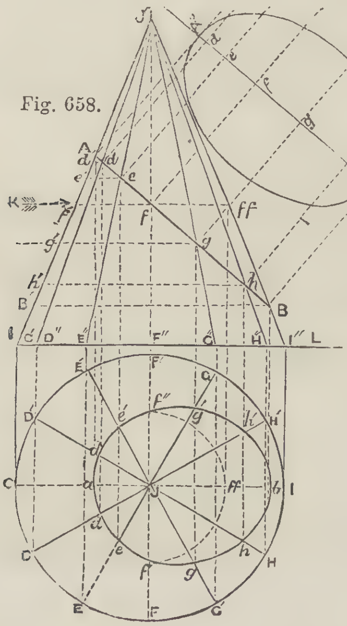
To metal-plate workers it will be a matter of importance to know the exact curve at which the metal must be cut, so that when formed into a cone it may be truncated—that is, cut off at the required angle.

We will, therefore, in the first place, develop the entire cone, and then mark on it the section line.

Fig. 659.—From any point, as J″, draw a line equal to J′ C′ in the elevation—viz., J″ C″—and with J″ C″ as radius describe an arc. On each side of C″ set off on this arc the equal distances C D, D E, etc., of the plan (Fig. 658).

Join I, I′ to J″, and the sector thus formed will be the develop-

Fig. 658.



ment of the cone on which it is now required to trace the line of section.

To do this, draw lines to J″ from the points D, D′; E, E′; F F′, etc., already marked on the arc I I′.

From the points d, e, f, g, h, and B, in the section line A B, draw lines parallel to the base of the cone, cutting the line C′ J′ in d', e', f', g', h', B′.

Now from C″ (Fig. 659) set off the length C′ A taken from Fig. 658—viz., C″ A′.

On the lines D′, D (Fig. 659), set off the length C′ d taken from Fig. 658—viz., D d, D′ d'.

Proceed thus for the other points, transferring the lengths on C′ J″ (Fig. 658) to the lines similarly lettered in Fig. 659, and through the points thus obtained draw the curve, the line in which the material would be cut, so that when I B and I B are brought together a truncated cone may be formed, the section of which on the line A B will be the ellipse A′ B′.

The student has already been reminded that if a solid be cut across, the parts will, when rotated on a centre, form an elbow —that is, they may be joined so as to turn a corner; or the parts may be turned obliquely to each other, forming an elbow of any required angle.

This principle holds equally good in relation to cylinders, and the following lesson is therefore (in order to save trouble of reference) repeated with additions and an enlarged drawing from "Projection."

Fig. 660 is the half plan, and Fig. 661, A B C D, is the elevation of a cylinder which it is required to cut so that when the parts are joined a double right-angled elbow pipe may be formed. The zinc-worker will at once see the usefulness of this study.

It is necessary that the student should again be reminded that whatever may be the required angle, the *section must be made at half that angle with the axis.*

Thus, if a pipe is to follow two walls which meet at an angle of 120°, each part must be cut at 60°. Therefore, in the present instance, draw the section lines E F and G H at 45° to the axis.

If now, supposing for the time the cylinder to be solid, the middle part be rotated on the pins I and J placed in the centres of the sections, and at right angles to E F and G H, the double elbow will be formed. The point E of the middle portion will move to F, and the point G will move to G′.

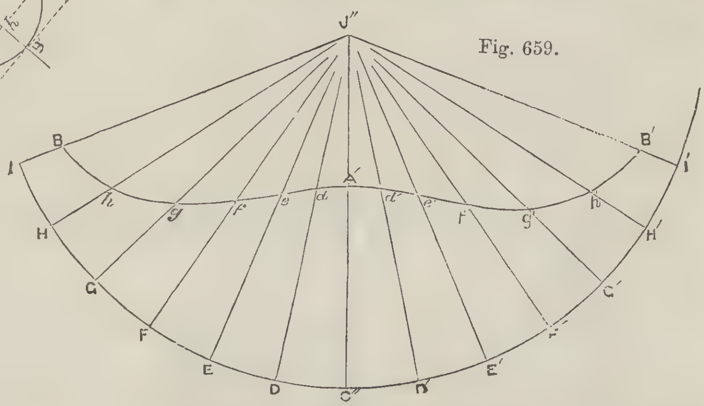
The point F of the middle portion will move to E of the lower, and H will move to H′.

In this operation it will be seen that the lower part is not moved at all, and that the upper part merely moves vertically and towards the right hand, but that only the middle portion is rotated.

The student is advised to get a cylinder such as this made of wood, cut and pinned as in the example.

With such a model he will easily realise the description here given, for if the lower portion be held with the left hand whilst the right hand grasps the upper, moving it in the required

Fig. 659.



directions, it will be seen that only the middle portion will be rotated.

Fig. 662.—To develop this cylinder, divide the plan into any number of equal parts, as shown at A, b, c, d, e, f, D in the half plan (Fig. 660).

Draw a horizontal line, and erect on it the perpendicular A′.

On each side of A′ set off the divisions b', c', d', e', f', D′, and b'', c'', d'', e'', f'', D″, taken from Fig. 660.

At D′ and D″ erect perpendiculars, and from B in the elevation draw a horizontal. The rectangle D′ B″ B‴ D″ (Fig. 662) will then be the development of the entire cylinder.

To trace on this development the lines in which the metal is to be cut so that the three parts may be accurately formed without any waste whatever, from b, c, d, e, f in the plan draw perpendiculars cutting the section lines in b', c', d', e', f'. From the points b', c', d', e', f', in Fig. 662, erect perpendiculars, and from the intersections b', c', d', e', f', and E, F, in Fig. 661, draw horizontal lines cutting the perpendiculars in Fig. 662 in E′, b'', c'', d'', e'', f'', F′. The line drawn through these points will be the curve required. The upper curve is obtained in precisely the same manner, the horizontals being drawn from the points in the line G H of Fig. 661.

To find the true section on either of the two lines, draw lines through the points b, c, d, e, f, at right angles to G H.

On each side of G H set off on these lines lengths equal to those drawn from b, c, d, e, f, to A D in the half plan (Fig. 660).

Join these points, and the ellipse thus drawn will be the true section.

Lessons on penetrations of cylinders and their developments will be found in "Projection."

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLII.—DAVID DALE, MANUFACTURER

BY JAMES GRANT.

THIS pioneer of the cotton manufacture, and founder of New Lanark, was born at the thriving little village of Stewarton, on the right bank of the Annock, in Ayrshire, on the 6th of January, 1739.

He was apprenticed to a weaver in Glasgow, and after due time, and gaining the necessary experience in his trade and in business, became a dealer in yarn in that city, and by his application and industry amassed a considerable sum of money, and early became distinguished for his philanthropy, and for that spirit of enterprise which has made the commercial capital of Scotland what we find it to-day.

In 1784 he conceived the idea of founding the large and handsome manufacturing village called New Lanark, situated on the right bank of the Clyde, about a mile above the ancient historical town of the same name, and in the same parish, for the manufacture of cotton. The credit of first introducing the manufacture into Scotland is due to Englishmen. In the year 1778 the first cotton mill was built at Rothesay by an English company, but was not long in being acquired by Mr. Dale, who became one of the most extensive cotton manufacturers north of the Tweed. "The mill," says Mr. Bremner, "was of small extent, and in the present day would be regarded as an almost insignificant concern; but it was the nucleus of one of the most important branches of industry that has ever been carried out in Scotland. The germ planted by English hands had a rapid growth; and before the Rothesay mill was sixty years old, there were 200 cotton factories in Scotland. Lanarkshire and Renfrewshire were chosen as the chief seats of the trade, partly on account of the abundant supply of water-power available, and partly because persons with the capital and enterprise required to carry on the new trade were more numerous in the west, while many of them had previously been engaged in manufacturing soft goods, and so were most likely to appreciate the value of cotton. Glasgow has all along been the centre of the trade, and nearly the whole of the cotton goods manufactured in Scotland are made by, or for, firms having their head-quarters in that city. In 1787 there were nineteen mills in Scotland, all driven by water."

Three years before that time, one of the earliest in Lanarkshire was that of Mr. David Dale at New Lanark, as he named it. He feued the site of the mill and village, with a quantity of ground around it, from the Lord Justice Clerk Braxfield, at a time when the spot was little more than a morass situated in a sloping dell; but the creative mind of the founder saw that it could be turned to greater account by diverting the waters of the Clyde into a power for turning machinery. The first mill was founded by him in 1785, and a subterranean passage of 300 feet was hewn through a rocky ridge for the purpose of forming an aqueduct. In having this dug, Mr. Dale discovered, says the old statistical account, a skeleton of the *Bison Scoticus*, or urus, described in Cæsar's "Gallic War." The cores of the horns, next the head, are fifteen inches in circumference.

The height of the fall of water from this aqueduct is twenty-eight feet. Three years afterwards, Mr. Dale built a second mill, with ranges of houses and cottages for his workpeople. By an accidental fire it was destroyed; but it speedily rose from its ashes, and became, as it is still, one of the most extensive manufacturing establishments in the county.

In connection with another speculator, Mr. Dale established the first works in Scotland for dyeing cotton Turkey red, and was a partner in the manufactory of inkles and tapes. By these means and his own sagacity, he amassed a large fortune, and ultimately became one of the magistrates of Glasgow. The rapid extension of the cotton trade in Scotland was owing, among other things, to the facility with which workpeople could be obtained. There was no regulation requiring special qualification in those who desired employment in the cotton-mills, and generally a few lessons sufficed to make boys and girls, and more especially adults, conversant with the simple duty of attending to the spinning machines or working at the loom. The wages paid exceeded those given to agricultural labourers, and the result was that the plough and spade were relinquished for the cotton mill; a redundancy of hands appeared, and then, the supply being greater than the demand, wages sunk.

About Mr. Dale's mills some 1,400 of the inhabitants of his new village were, and are, constantly employed, and it became a settled rule that no one was to establish himself there, unless employed directly or indirectly about the mills, which are now, perhaps, the most healthy in the United Kingdom. At New Lanark there is none of the confined atmosphere, or other disadvantages which attend similar establishments, created within the crowded localities of our large manufacturing towns. The situation, says a statist, is open, healthful, and pleasant, from its beautiful situation on the Clyde; and the utmost attention was, and is, paid by the proprietors and managers to the cleanness of the dwellings, and the well-being of the people. Until they were ten years of age, no children were allowed to enter the mills, and prior to entry a system of education was compulsory on the parents.

The school which is thus patronised by the company is called the Institution, and by its means "New Lanark has escaped the stigma, which attaches to many other manufacturing communities, of permitting their youth to grow up in immorality and ignorance. The inhabitants, therefore, from this early judicious training, are, in general, an orderly, intelligent, and most creditable class of people, and although originally gathered from many different parts of the kingdom to found the new village, their national characteristics have been merged or amalgamated into a combination which has produced distinctive feelings and habits peculiarly their own." ("Stat. Acct. Scot.")

On one occasion, we are told that, in 1791, a vessel carrying emigrants from the Isle of Skye for America was driven by stress of weather into Greenock, and some 200 persons were put on shore in a very destitute condition. Mr. Dale, whose humanity was ever wakeful, offered them immediate employment, which they gratefully accepted. Soon after, with a view to prevent further emigration to America, he publicly notified to the people of Argyleshire and the Western Isles, the encouragement given to all who were industrious at his cotton-mills, and in 1792 he undertook to erect houses for 200 families. In the following year these comfortable little dwellings were all finished, and occupied by the hardy denizens of the mountains.

Latterly, Mr. Dale, as years advanced upon him, found himself compelled to relinquish the more active management of the mills, works, and village to his son-in-law, the famous Mr. Robert Owen, the propagator of what is called Socialism, and whose visionary notions and projects for a complete regeneration of the state of mankind, by a species of communism, made his name unhappily notorious throughout Britain.

For many years, however, he devoted much attention to the education of the children, and propounded several plans for improving the condition of the inhabitants. These were at first regarded with a friendly eye by those who were used to the philanthropic and almost parental care of David Dale, but have since been deservedly scouted as incompatible with the well-being and framework of social humanity. It is but just, however, to record, that Mr. Owen's name is seldom mentioned by the villagers without respect, and many are the tales and traditions preserved among them of personal kindness and generosity which he displayed in his intercourse with the generation that is past.

David Dale died on the 17th of March, 1806. He was the founder of an independent sect in Glasgow, whose peculiar tenets somewhat resemble those of the Glassites.

MINING AND QUARRYING.—XXXV.

BY GEORGE GLADSTONE, F.C.S.

PYRITES.

IRON PYRITES — GEOLOGICAL DISTRIBUTION — FOREIGN SUPPLIES — ANALYSIS — MAGNETIC PYRITES — CHALCOPYRITE — TIN PYRITES — MISPICKEL — COBALT PYRITES — MANUFACTURE OF ARSENIC — USES — POISONING — ANTIDOTES — MARSH'S TEST.

PYRITES has frequently been referred to in former articles of this series, as well as in Nos. XI. and XII. of "Chemistry applied to the Arts;" but its commercial value will probably be better appreciated, and the distinction between the different

sorts better understood by bringing them all together under one heading.

The name was first given, and properly belongs, to the sulphide of iron, because if one piece is sharply struck by another a shower of sparks will result. But the double or compound sulphides of iron, and some of the other metals, bear a strong external resemblance to that of iron alone, and the use of the term has gradually extended to these also. The commonest of these are copper pyrites, the ore of copper most abundant in this country, and mispickel, the prevailing metal in which is arsenic. Tin pyrites contains both tin and copper as well as iron, and hence is sometimes called bell-metal ore.

Iron pyrites is very widely distributed in nature, being found in geological formations of all ages, even up to the Tertiary, and under almost equally various conditions. It is only recently, however, that it has been turned to much use, as the presence of sulphur prevents its employment in the manufacture of iron in a country which is so abundantly supplied as England is with ores free from that objectionable ingredient. The chief uses are in making sulphuric acid and copperas.

In Cornwall it is termed "mundic" by the miners, and it occurs there in the regular mineral lodes, being a frequent accompaniment of tin and copper ores, especially in those portions of the lodes which are nearest to the surface. If sufficiently rich in mineral, it is dressed and sent to market.

It occurs to an inconvenient extent in many of the coal-beds. In some cases the coal is so disseminated with it as to be rendered almost useless as fuel. A notable instance of this occurs in Staffordshire, where one of the seams is known as the "stinking coal," on account of the disagreeable sulphurous smell which it has, and which becomes stifling when it is burnt. In most of the workable coals, moreover, strings and detached masses of pyrites occur, which are called "brasses" by the colliers, in consequence of their bright yellow metallic appearance. These pieces have to be picked out from the good coal by hand, and are sold in considerable quantities to the chemical manufacturers, who use them principally for making copperas or sulphate of iron.

The upper Secondary and the Tertiary formations often contain pyrites in considerable quantity. It is one of the necessary ingredients of a good alum shale, as may be more fully seen in reference to "Chemistry applied to the Arts," No. XII.; and many of the beds of lias rock, besides that near Whitby which is selected for the alum works, are full of nodules of pyrites, the mineral being generally deposited around some organic nucleus, such as an ammonite or other shell. Some beds of the upper Oolite are highly charged with this mineral, sufficient indeed, in the neighbourhood of Kimmeridge, to have caused spontaneous combustion of the stratum of clay through the heat evolved by the decomposition of the pyrites. In the chalk nodules of it are common, and on account of their sulphurous smell, are supposed, by the country people in many districts, to be thunderbolts! The fossil wood, beds of which are common in the Wealden and Tertiary clays, is generally pyritised, abundant instances of which occur in the Isle of Wight, at Bognor, the Isle of Sheppey, and other places.

These less important deposits have been more particularly referred to, because they are somewhat liable to be overlooked altogether, in consequence of their lying out of the regular mining districts. The consumption of pyrites in this country is now calculated by hundreds of thousands of tons, and while all available deposits on the Continent are sought out to supply our manufacturers, it is a pity to neglect any which might be made available within our own shores.

Almost the only pyrites mines in the kingdom which are worked strictly for the sake of their ore, are those situated in the lower Silurian schists of Wicklow, where the mineral occurs in the massive state. These, together with the Cornish and other British ores, kept all the chemical works supplied up to about sixteen years ago; but the increase in the manufacture of acid has been so rapid of late years that enormous quantities are now imported from abroad.

The principal foreign sources available for our manufacturers are necessarily limited to such situations that the mineral can be brought to this country at a cheap rate. The imports are, therefore, chiefly from Huelva in Spain, Pomaron in Portugal, Hitteren and Stavanger in Norway, and from sundry mines in Belgium and West Prussia. In most of these places the pyrites occurs in such large quantities as to form a solid mass, which is quarried rather than mined. At the Spanish and Portuguese works the mineral is so compact and uniform in its character that the operations can be conducted by machinery instead of requiring manual labour, and the cost per ton of all the necessary operations down to the time of shipment can be estimated to a mere fraction.

In Hildesheim, Hanover, close to the ancient city of Goslar, another very remarkable mass of this ore occurs, but the produce is entirely consumed in the neighbouring village of Oker, which is exclusively devoted to chemical and metallurgical works. The Rammelsberg mine is known to have been worked almost uninterruptedly for the last 900 years, and there seems no prospect at present of its being worked out. The hill rises to a considerable height above the town; the deposit of pyrites commences high up in the interior of the hill, and as it descends it widens out in a wedge shape, which has divided into two branches in the lower levels, but still continues to yield a practically unlimited supply of ore. The mineral is so solid in its character as to yield very sparingly to the ordinary tools of the miner, and a totally different system of mining is therefore carried out here. Timber and brushwood are very abundant on the mountains in the immediate neighbourhood, and they are let down into the mine in very large quantities through one of the upper shafts, which is specially devoted to this purpose, and this is ranged against the walls of ore wherever operations are to be carried on. At the close of the week's work the wood is set on fire and left to burn all Sunday. When the fire has spent itself, and the galleries have cooled down, the miners enter and break away the ore which has been cracked or rendered tender by the heat of the burnt timber.

The chemical composition of the sulphide of iron, FeS_2, would indicate the following per-centage proportions of the two elements—iron, 46·7, and sulphur, 53·3—were the specimen perfectly pure. But the mineral taken in bulk will always contain more or less earthy matters and other metals. The following estimations of the per-centage of the principal ingredients in sundry commercial samples will show what proportions of sulphur and other substances of value should be looked for:—

	Huelva.	Pomaron	Theux, Belgium.	West Prussia.	Hitteren.	Wicklow.	Walker Colliery Brasses.	
Sulphur .	44·6	49·3	45·0	45·6	44·5	44·2	40·5	38·1
Iron . . .	38·7	41·4	39·7	38·5	39·2	40·5	36·3	34·4
Copper .	3·8	5·8	0·0	0·0	1·8	0·9	0·0	0·0
Zinc . . .	0·3	0·0	1·8	6·0	1·2	3·5	0·0	0·0
Coal . . .	0·0	0·0	0·0	0·0	0·0	0·0	17·9	14·4

The rest consists of earthy matter and traces of other minerals, among which the rare metal thallium is found, especially in the Belgian and Westphalian pyrites. The proportion, however, even in the richest of these, does not exceed $\frac{1}{4000}$th part of the whole. The Spanish and Portuguese ores are rather difficult to manage on account of their liability to fuse at the temperature produced by the burning of the sulphur, and a special arrangement of the kiln is necessary so as to afford an unusually large area in proportion to the weight of the charge. These ores contain sufficient copper to enable it to be extracted with profit, which therefore considerably adds to their value. Less than 1 per cent. of copper is not found to be worth extracting. The residue, after the burning of the pyrites in the vitriol works, is generally treated as waste, but it can be used for making iron, provided it is thoroughly calcined, in order to drive off the last traces of sulphur.

There is another combination of iron pyrites which is magnetic. It consists usually of 7 parts of iron to 8 of sulphur, and contains, therefore, 60·5 per cent. of the former to 39·5 of the latter. In some cases the iron amounts to 63·6, leaving only 36·4 of sulphur. It is, therefore, relatively poor in sulphur as compared with the ordinary sulphide, and is not in favour with manufacturers. It is frequently met with in the Cornish mines, as well as in North Wales and Scotland.

Copper pyrites, called by mineralogists chalcopyrite, is the prevailing form in which copper ores occur in this country, and consists of a double sulphide of copper and iron, Cu_2S,Fe_2S_3, yielding 34·5 per cent. of copper, 34·9 of sulphur, and 30·6 of

iron. The mining, dressing, and smelting of it has already been described under the head of "Copper."

Tin pyrites is often found in Cornwall in the search for the usual tin ore, and consists of a mixture of the sulphides of tin, copper, and iron.

A more important is mispickel, also found in no inconsiderable quantity in the same localities. It may be known by presenting the usual crystalline appearance of pyrites, while at the same time it has lost nearly all its usual yellow colour, and appears only of an impure white. It is an arsenio-sulphide of iron, represented by the chemical formula $FeAs_2,FeS_2$, and yielding 46 per cent. of arsenic, 34·3 of iron, and 19·7 of sulphur. It will be seen, therefore, that this is still more deficient in sulphur than the foregoing, and though it is used to some extent in making oil of vitriol, it is of more value as a material from which to make white arsenic. The sulphuric acid made from mispickel is always impregnated to some extent with arsenic, which is objectionable.

Cobalt pyrites consist of a combination of arsenic alone, or arsenic and sulphur, with cobalt. Iron, nickel, and bismuth are often associated to some extent with these ores, so that the analyses will vary considerably. These are used primarily for the sake of the cobalt, and are therefore referred to more particularly in Article XXXIII.

The arsenic contained in the mispickel and the cobalt pyrites is of sufficient importance to be preserved from being dissipated in the atmosphere, where it would exercise an injurious effect on account of its being one of the most active poisons. The manufacture of arsenious acid, the ordinary form in which arsenic is employed, is therefore a trade of very considerable importance, especially in Germany, where these descriptions of ores are much more abundant than in England.

The process of separating the acid from the metals with which it is combined is a simple one, requiring nothing more than roasting in a suitable furnace. This is closed in, and made in the form of a muffle, so that the heat is only derived from the flues which pass all round it. A small fire is sufficient, as it is only necessary just to raise it to a red heat for a time, after which the heat evolved in the oxidation of the charge will help to maintain it during the rest of the process, which usually lasts about twelve hours. The door in front of the muffle is left open during the roasting, so as to supply an abundance of air to oxidise the arsenic, and the floor of the muffle is made to slope a little from the door upwards, towards the pipe which leads to the condensing chambers, so that the current of air shall always set in that direction. The arsenious acid is thus carried through a series of large rooms, connected by openings the one with the other, and gets gradually deposited in the course of its progress. The poison tower, as this pile of chambers is generally called, terminates above in a lofty chimney. The purest acid is condensed in the lowest of the chambers. These are emptied periodically, whenever a considerable quantity has collected, and the acid is finally purified by sublimation.

Arsenious acid is used to some extent in glass-making, to destroy the colour caused by the presence of iron; and also by colour manufacturers and dyers, as the arsenite and arsenio-acetate of copper produce very beautiful greens. Its virulence as a poison leads, unfortunately, to its improper use on some occasions; and the fact of its external appearance bearing a great resemblance to salt or pounded loaf-sugar, has not unfrequently led to its being taken by mistake. The simplest antidote that can be readily procurable in such an event is a liberal administration of calcined magnesia; a large quantity of the hydrated sesquioxide of iron will also render it innocuous by combining with it and forming an arsenite of iron, which is insoluble, and therefore exerts no influence upon the system.

Fortunately there are very simple and delicate tests for arsenic, so that the most minute quantities will not escape detection. The smallest portion of any substance containing arsenic, when heated on charcoal before the blowpipe, will emit such a powerful odour, resembling garlic, that its presence cannot be mistaken; but there are tests much more delicate and conclusive than this.

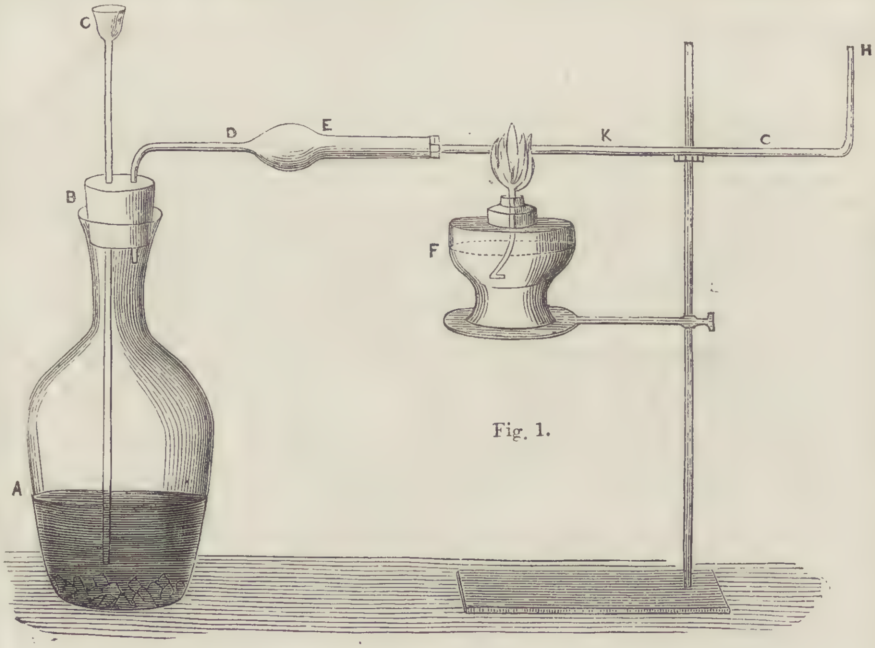


Fig. 1.

What is commonly known as Marsh's test can be applied in two or three different ways. The simplest form is that of a common U-tube, the one end of which is drawn out to a point. In the bend of the tube is put some dilute sulphuric acid, some pure zinc, and the article supposed to contain arsenic. If the supposition be correct, a gas will be evolved containing a mixture of arsenic and hydrogen, which can be burnt as it escapes from the pointed end of the tube, by merely applying a light. On placing a plate of white porcelain in the flame the arsenic will be found to leave a residue, which will cause a brownish metallic stain; whereas, if the article tested is free from arsenic, hydrogen only will be evolved, which will not discolour the porcelain.

The annexed drawing represents an improved arrangement. A is a flask, in which the suspected article is put along with some water and metallic zinc. The apparatus being adjusted, and the cork, B, made to fit tightly, sulphuric acid is poured in through the funnel, C. As the gas is driven off it passes out through the pipe D, the bulb of which, E, is filled with dry cotton wool, to absorb any moisture. Supposing for the moment that the spirit-lamp, F, is not lighted, the gas will pass out through the tube G, and can be lighted at the orifice H, and the test already described can then be applied. But if instead of this the glass tube be heated red-hot by the flame of the spirit-lamp, F, the arsenic in the gas will be separated and deposited in the metallic state in the interior of the tube at K, as the heat at that part will not be sufficient to keep it in suspension. The whole of the arsenic contained in the flask can be collected in this way and afterwards dissolved out and weighed. The chief precaution to be taken is to ensure that neither the zinc nor the sulphuric acid which are used in the test contain any arsenic, a case which is not at all uncommon, but one which is easily ascertained beforehand by trying the experiment first with them alone before adding the suspected ingredient.

COTTON-SPINNING.—II.

By J. Robertson.

CARDING—CARDING-ENGINE—CARDING CLOTHING—EQUALISATION OF THE SLIVERS.

In our last paper on this important branch of one of the greatest of England's industries we gave an account of the first step in the preparation of cotton yarn—namely, that of scutching or cleansing the fibre from dirt and extraneous matter. We will now describe in detail the next process—that of carding. Carding is performed by passing the cotton between two sets of fine wire points which are bent in opposite directions, and which are moved against each other, so that the fibres taken hold of by both at the same time are combed and laid parallel. In olden times this was performed by a pair of hand-cards upon the knee. Towards the close of the last century, however, the inventions of Arkwright, Hargreaves, and others, demanded an improvement in this preparatory manipulation, which had been found totally unequal to the requirements of the increasing trade. Stock-cards succeeded to the hand-cards, and these again were superseded by cylindrical cards, from which, in the first instance, the carded cotton was taken off in short rolls. The cylinder carding-engine has been the object of many important improvements, which have rendered carding one of the most efficient and beautiful of all the operations carried on in the spinning factory. The cotton which enters in the form of a tangled web or fleece, largely impregnated with foreign matter, issues a soft pure ribbon, technically called a *sliver*.

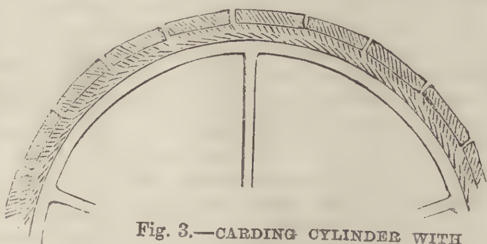


Fig. 3.—CARDING CYLINDER WITH FLAT CARDS.

Fig. 4.—SAW-TOOTH FILLETING FOR TAKER-IN.

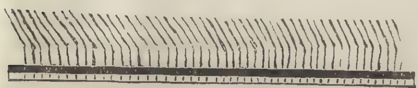


Fig. 1.—CARDING CLOTHING OF FINE WIRE POINTS FOR FLATS AND ROLLERS.

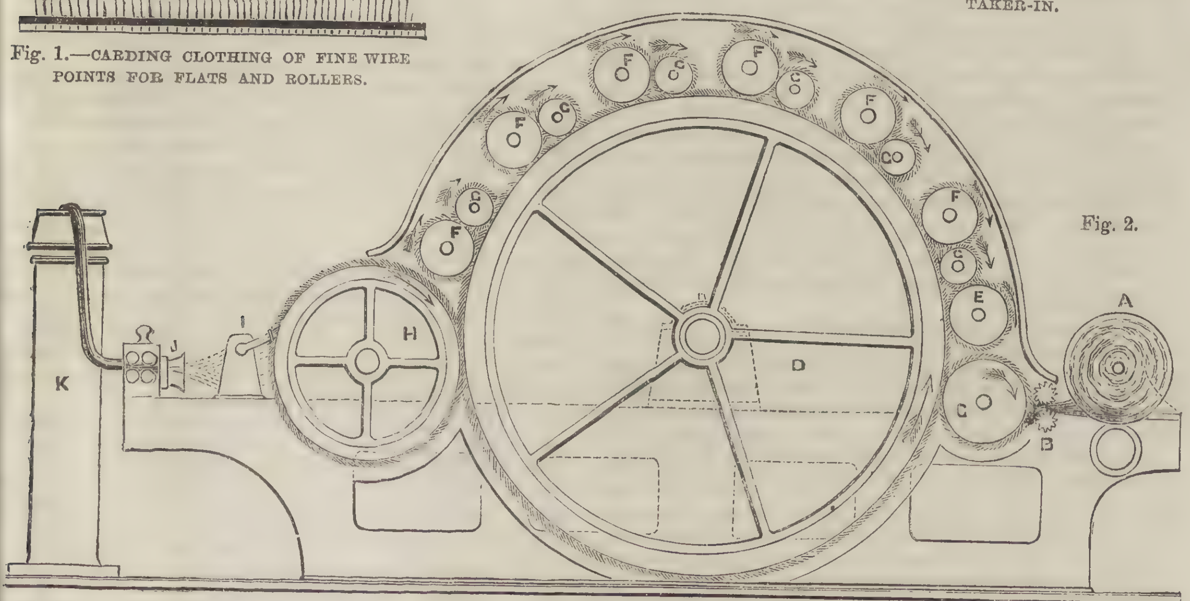


Fig. 2.

Fig. 2.—SECTIONAL VIEW OF CARDING MACHINE.

As in the case of many other machines, opinions differ in respect of some of the details of the carding-engine. The principle is the same in all, and their main features are very much alike. A large iron cylinder thirty-six to forty-eight inches in diameter, and about the same in length, revolving upon a cast-iron frame, is partially surrounded by *flats* or rollers, or flats and rollers combined. All of these are "clothed" with fine wire points fixed in a combination of cloth and india-rubber (see Fig. 1). Formerly these points were set in leather, which, however, from its lesser elasticity, has been thrown almost entirely out of use. These rollers and flats are set as close to the main cylinder as possible without touching. The process of carding may be better understood by referring to Fig. 2, in which a sectional view of the machine that is ordinarily used in carding cotton fibre is represented. It will be remembered that after the operation of scutching is complete, the cotton fibre has been brought into the condition of a thick felted web which is wound up in the form of a bobbin and called a *lap*. This lap which has been brought from the scutching-house is shown at A, resting upon a roller which unwinds it and delivers it without any strain to the fluted feed-rollers, B. So loosely is the web felted that the very slightest degree of tension would tear it asunder. As soon as the cotton has passed the feed-rollers it is seized and carried round by the "taker-in," C, until it in turn is stripped of it by the main cylinder D, the teeth upon which are bent in the same direction at the point of approach, and go at a much greater velocity. Apart from the slight degree of combing which it gives the cotton as it passes the feeding-rollers, the only duty required of the "taker-in" is indicated in its name. This roller is usually "clothed" with a strong coarse card, so that it may be less liable to receive injury from any hard substance which may have passed with the cotton through the scutching-machines, or from its taking hold of matted flakes from the feed-rollers. In some cases this roller is dispensed with altogether for the sake of economy; but it is a short-sighted policy, as the fine points of the main cylinder are very susceptible of damage from the causes mentioned. At E, which is usually called a "dirt-roller," the carding proper commences, the wire upon it being set against the wire upon the large cylinder; and this is the case with all the other rollers, F, at each of which the fibres are held until they are drawn parallel, whilst the broken pieces of shell, leaf, etc., get fixed between the points of the wire, and are either thrown out beneath the machine along with the short staple cotton, or are at regular intervals brushed out by the attendants. These rollers move slowly in the opposite direction from the large

cylinder, so that at the point of approach they retrograde from it. To prevent them from becoming choked with cotton, each of them is brushed or cleared by smaller rollers, G, called *clearers*, having the teeth of the cards bent in the same direction at the point of approach, and revolving much more rapidly. These in their turn again are stripped by the large cylinder, the periphery of which goes at a very much higher velocity. Thus the process of carding and "cleaning" goes on at each successive set of rollers until the "doffer," H, is reached. Here the carding is complete, and the film of cotton which adheres to the surface of the doffer is taken from it by a rapidly reciprocating comb, I. Its appearance now is that of a light, airy cobweb, which is immediately drawn together through a trumpet-mouthed aperture by a set of small calender rollers at J, whence it is taken by the coiler, and coiled and compressed into the can K.

The under side of the main cylinder is commonly cased with a wire grating to prevent any but the shortest fibres being thrown out. A mahogany cover encloses the engine on the upper side, and prevents the dust and short cotton filling the atmosphere of the apartment. This *roller* card is the one most commonly in use. *Flat* cards are, however, largely in favour too, their peculiar feature being that instead of the large cylinder having small rollers surrounding it, the card clothing is mounted upon flat boards or bars of iron (see Fig. 3). As it is obvious that carding can only take place where the opposing cards come together, and as in the case of the roller carding-engine that can only occur seven or eight times when the periphery of main cylinder and rollers touch, it seems reasonable to suppose it to have a disadvantage compared with that which by means of narrow flats can form a continuous semicircle of card. These *flats* in many cases are stripped or cleared at short intervals by the hand with a piece of card sheeting fixed to a board, which entails a greater expense for attendants. To obviate this disadvantage, by rendering the card self-stripping, several very ingenious devices are used. In some the flats are made to rise in succession in a direction perpendicular to the axis of the main cylinder, and when at their highest point a stripper moves forward and cleans them from waste cotton, upon which they immediately return to their place. Another and more perfect arrangement is that by which an endless chain of flats is made slowly to revolve, so that each flat is successively brought under the operation of a reciprocating comb or stripper. Other carding-engines have the main cylinder partly surrounded by rollers and partly by *flats*.

It is a matter of vital importance to keep the card-points well sharpened, otherwise it is impossible to produce a clean, regular fleece. For this purpose once a month or so an emery roller is geared upon the top of the main cylinder and doffer, and after being carefully set and brought to bear upon the wire, the cylinder and roller are driven rapidly against each other, until all the points are made perfectly level and sharp. To maintain them in a proper carding condition, a concave board covered with emery is held gently to the wire at frequent intervals. To grind and sharpen the *flats* or rollers, it is necessary to take them out of their places, and let them run for a short time against an emery roller in the grinding machine. This is generally done every alternate week.

Equally important with the sharpening of the cards is their adjustment or *setting;* that is to say, the cards upon the flats or rollers must be perfectly parallel with those upon the main cylinder, and so close that they almost touch. This is very simply done by means of screws, which raise or lower the rollers or flats in a radial direction. Though sometimes a small slip of thin iron is used in *setting,* by passing it between the two sets of points, yet on account of the flexibility of the wire this is not a safe method. The slip may have passed easily between them, and yet in working it may be found that they are rubbing upon each other. A skilful workman can have no difficulty in dispensing with such a gauge by a careful use of eye and ear.

The seeds and broken leaves which have got fixed between the wires of the main cylinder are stripped out by the hand several times a day. Also the refuse of these, and of *fly*, or short staple cotton, which has gathered below the machine, are removed by attendants from time to time.

The relative speed of the feed-rollers and the doffer is usually as 1 to 100, so that one yard of *lap* is drawn out to one hundred yards of sliver. This *draught* may be increased or diminished by changing the pinions which drive the feed-rollers. The circumferential velocity of the main cylinder is about 15,000 or 16,000 feet per minute, whilst that of the doffer is only about 70 or 80. The carding rollers require to revolve at such a speed as will bring every part of their circumference into contact with the *clearers* sufficiently often to prevent the cotton fibres gathering upon them in too thick a film. The clearers, again, must overrun considerably the carding rollers, so as to clear them out thoroughly.

There are two forms of card clothing for cylinders—viz., sheets and fillets. The former is about four or five inches in width, and of a length suited to the length of the cylinder; the latter is usually about two inches wide, and in length sufficient to cover the cylinder when wound upon it spirally. Filleting is almost universally used now for cylinders and rollers, whilst sheeting is confined to the flats.

Card clothing also varies in the number of wire-points upon a given space, and is designated accordingly. If there are one hundred upon four inches, it is called No. 100; one hundred and twenty, No. 120. These different numbers are made use of according to the particular function of the part upon which the card is fixed. Generally speaking, the taker-in has either a very strong card of a low number or a saw-tooth filleting, as Fig. 4, in which the ground-work is leather instead of india-rubber. The main cylinder is clothed with No. 90 when the cotton being carded is for low numbers of yarn, and with No. 100 or No. 110 when for the finest; the carding roller with No. 90, and the clearer No. 100; whilst the doffer, as a rule, is clothed with filleting about twenty numbers finer than that of the main cylinder. The fine cards enable the reciprocating comb to take off the carded cotton in a finer and more regular web, and the cotton having already been subjected to the carding of the rollers or flats has no power to injure the wire.

In the case of coarse yarns the cotton is only passed through one carding-engine; but when the yarn to be spun is finer than No. 60 it is subjected to a second, and the system is technically called "double carding." In this case the *slivers* produced by the *breakers*, as the first set of engines is called, require to be restored to the form of a lap, before they can be passed through the *finishers*. For this purpose the lap-machine or doubler is introduced. Here the slivers are run side by side upon a wooden spool or bobbin, after being compressed by calender rollers. Two or three large bobbins, when filled, are placed side by side upon the finisher, and are unwound and carded in the same manner as the laps from the scutching-machine in the breaker. There is no necessary difference between the breaker and finisher card, but commonly the breaker is furnished with rollers, whilst the finisher has flats, and the card clothing is ten to twenty numbers finer.

The objects of the carding process have now been effectually accomplished, the fibres having been laid parallel, short staple cotton and fragments of seed and leaf having been removed. But it must be obvious, that even with the greatest care on the part of the operatives, a difference of grist or size, or number of fibres in a section of the different slivers, must exist to a greater or less degree. All the slivers having to pass through the same ultimate operations, any difference in size at this stage would be carried forward to the finished yarn, and thus render it unsuitable for the weaver. To equalise the slivers, and at the same time to straighten the fibres and bring them closer together, is the purpose of the drawing-frame.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLIII.—SIR RODERICK IMPEY MURCHISON, K.C.B., D.C.L., ETC. ETC.

THIS distinguished philosopher was born in Ross-shire in 1792; he was the son of Kenneth Murchison of Taradale, and the great-grandson of one well known in Highland history as the faithful factor of Seaforth, Donald Murchison, who, when the disarmament of certain clans was ordered by General Wade in 1724, sold to that officer all weapons that were useless, while he took especial care that the really serviceable arms of the district—the long-barrelled muskets, the good claymores, the

dirks, skeans, and pistols—were well oiled, packed in tough bull-hides, and concealed in secret places, till King James's son should come to claim his father's kingdom.

Young Murchison was educated at Durham Grammar School, from whence he went to the Military College at Marlow, and in 1807 was appointed to an ensigncy in the 36th or Herefordshire Regiment, with the first battalion of which, under Lieutenant-Colonel Robert Burne, he embarked for the Peninsula, and carried the colours under Moore at the battles of Roleia, Vimiera, and Corunna, and subsequently under Wellesley. He was a lieutenant in 1811, and continued in the service till 1816. Prior to this, on his promotion to the rank of captain, he served on the staff of his uncle, Sir Alexander Mackenzie, with the Sicilian army of occupation.

On the final conclusion of peace he quitted his troop in the 6th or Inniskilling Dragoons, and retired from the service, after his marriage with a daughter of Lieutenant-General Hugonin, and from thenceforward science became the absorbing pursuit of his life. In this new choice he is said to have been greatly influenced by Sir Humphry Davy; but in all his works there lingered traces of the soldier.

So early as 1831, he had applied himself to a systematic examination of the older sedimentary deposits in England and Wales, and after five years of constant labour, succeeded in establishing that which he named "the Silurian system," comprehending a succession of strata that lie *beneath* the old red sandstone, and which seem to approximate to the deposits that preceded the existence of plants and animals. "This system (named from its occupying those counties which formed the ancient kingdom of the Silures) is divided into the Upper Silurian, consisting of Ludlow and Wenlock rocks; and the Lower Silurian, of Caradoc and Llandilo rocks. The same succession of strata was found in the west of Europe, and in North and South America; and Mr. Murchison next traced the extension of the Silurian system to Norway and Sweden, and particularly to the vast empire of European Russia, where the relative position of the older rocks has suffered little or no disturbance from the intrusive agency of fire." Prior to this, in the year 1825, he had become a member of the Geographical Society.

Under the countenance of the Imperial Government, in 1840, with Count Keyserling and De Verneuil, he entered upon a work which gradually extended until it had embraced important observations in nearly every portion of Russia, Poland, Germany, and Scandinavia, being a scientific expedition equalled only by those of Humboldt in South, and of Lyell in North America. The result of this learned tour was the foundation of "the Permian system," the uppermost member of that great Palœozoic series, which, as Professor Phillips says, "owes to Sir Roderick many of its foundation-stones." An account of the expedition was published in two large volumes in 1845. In 1841, on the presentation of the first report to the Emperor Nicholas, he gave Mr. Murchison the second class of the Order of St. Anne in diamonds, and a magnificent colossal vase of Siberian avanturine on a column of porphyry; and three years later, on his completion of the Russian survey, he received the Grand Cross of St. Stanislaus, and was made a member of the Imperial Academy of Sciences. Upon his return to Britain he was knighted by her present Majesty.

The importance of his geological discoveries will be better understood by the reader when he is told that they led to the consent of geologists to form the principle "that it is by groups of associated organic forms, indicating life periods, that the chronology and sequence of the rocks and their remains are to be estimated."

It was with sensations of very great disgust that Sir Roderick saw his facts—which led the chain of life from the Azoic rocks up to the world of man—laid beneath such sceptical superstructures in Germany, as those with which Britain became familiar in the work entitled "Vestiges of Creation."

In the year 1844, when bringing out his large work on "The Geological Structure of Russia," he instituted a comparison between the rocks of Eastern Australia and those of the auriferous Ural mountains, and this led him to the conclusion that gold must exist in that quarter of the world. So convinced was he of the correctness of his hypothesis, that in 1846 he even urged some Cornish miners to emigrate to New South Wales, there to obtain gold from the rich alluvial soil, in the same manner in which they extracted tin from the gravel of their native country.

In 1848, he addressed Earl Grey, then Colonial Secretary, to the end that Government might adopt measures for the interests of the Crown; but his advice was not taken, and it was only in 1851, three years later, that the so-called *discovery* of the gold-fields in Australia took place.

In 1849, when, as a tardy recognition of their services, the war decoration was granted to the surviving officers of the Egyptian and Peninsular armies, Sir Roderick received a silver medal with three clasps for Roleia, Vimiera, and Corunna.

He was four times President of the Geological Society, and fourteen years President of the Royal Geographical Society. He was a member of the Royal and Linnæan Societies; member of the Academies of St. Petersburg, Berlin, Brussels, Copenhagen, Stockholm, Turin; and was long a Trustee of the British and Hunterian Museums, and of the British Association for the Advancement of Science, of which last body he was one of the founders.

It was in his capacity as President of the Geographical Society that he first became acquainted with his countryman Dr. Livingstone, his devotion to whom, and furtherance of whose schemes for the exploration of Africa, have been so unwearied. During their career, few men of science have met with so full a recognition of their services as Sir Roderick Murchison.

In 1855 he succeeded Sir H. De la Beche in the office of Director-General of the Geological Survey of the British Isles; and his latest labours have been repeated examinations of the volcanic rocks of his native Highlands, for which the Royal Society of Edinburgh conferred upon him their first Brisbane or gold medal. The Copley medal, or first honour of the Royal Society of London, was awarded to him in 1846; and from an early period he held the honorary degree of M.A. of the Universities of Cambridge and Durham. He also held the diplomas of D.C.L. and LL.D. In 1866 he was created a baronet of the United Kingdom.

In the foundation of the Permian system, he had at first indicated less facility for the reception and adoption of new facts and ideas than his friend Sir Charles Lyell, author of so many well-known geological works; but the younger discoverers remembered that the venerable Murchison had been also a theoretical pioneer in his day; and though they at times thought that he had become so identified with the Silurian period as to look upon its sceptical critics with pain, they never failed to award him their esteem, respect, and affection.

He has taken his place with Buckland, De la Beche, and Lyell as a father of British geology; he has received the homage of nearly every foreign scientific society, and his name has been bestowed upon the Murchison river in Western Australia, on a great mountain in New South Wales, and upon a strait at the head of Baffin's Bay, the entrance of which was long known to navigators as Whale Sound. It has also been given to other places in British North America, in Greenland, and in India. But with Australia his name is most popularly associated, since it was he who first predicted that its soil was full of gold.

"Personally," says a writer, "Sir Roderick was most esteemed by those who knew him most intimately. He has never failed, by advice or pecuniary means, to aid any man of ability who desired to pursue his studies or discoveries, and many a youth in England has reason to remember him as a generous benefactor. He was free from jealousies and full of personal enthusiasms. None who were present at the meeting of the British Association at Bath in 1864 will forget the serene joy with which Sir Roderick sat by his friend Livingstone, or the emotion with which he gave the thanks of the Association to Sir Charles Lyell for his address. When he alluded to the recent honour of a baronetcy which Her Majesty had bestowed upon Sir Charles, he was most eloquent, and sat down amid loud plaudits. Faults of manner he may have had, and there are faults in his statements of theoretical geology; but it is very certain that since the time when Voltaire imagined that the shells of Geneva had been dropped from the wallets of pilgrims, the knowledge of the vast changes the world has undergone has advanced in rapidity, as some think, beyond any other knowledge, much of the honour is due, where it was bestowed, on Sir Roderick Murchison."

Prior to his giving to the world his Silurian system, the rock-

history of the earth was but little known, and the strata beneath the old red sandstone formation had been "a scientific No Man's Land;" and it was in 1851, when defending his theory in an address delivered at the Royal Institution, on the former changes of the Alps, that he ended an impressive statement of the evidences, showing that there had been a succession of creations from lower to higher types of life, in the ascension from inferior to superior geological formations; and he denounced the "Vestiges of Creation," and the whole theory of the transmutation of species, with great warmth and in forcible language. And to these views he held, even after the former theory had passed into the doctrine of evolution as held by Dr. Charles Darwin.

In recent years, Sir Roderick made a great addition to British geology by establishing in the north-western Highlands of Scotland the existence of the fundamental stratified deposits of the United Kingdom, these, the so-called Laurentian rocks, being still older than the Cambrian and Silurian systems.

In 1863 he was made Knight Commander of the Bath, and in the following year he received the Prix Cuvier from the French Institute, and the Wollaston Medal at home, for his geological labours; and his love of study and enthusiasm in the cause of science were unwearying, and ceased only with the end of his long and useful life.

He died on Sunday, the 25th of October, 1871, at his town residence in Belgrave Square. He expired about half-past eight in the evening, and in the seventy-ninth year of his age.

CIVIL ENGINEERING.—XXIII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

THE finest timber bridge which was probably ever constructed, whether for length of span, or for lightness and elegance in construction, was that built over the Schuylkill at Fairmont, U.S., by Wernway, and destroyed by fire in 1838. It consisted of a single arch, having a span of 340 feet clear from one abutment to the other. Fig. 63 shows a side view of this bridge.

Its versed sine was 38 feet, and the breadth of the carriage-way 30 feet. To ensure the internal soundness of the timber, every piece of large dimensions was sawn through the middle. The main ribs were laid three deep, and strongly bound together with wrought iron. The king-posts were twenty-nine in number, radiating from the centre of the circle of which the arch formed a portion. These were kept in their respective positions by timbers fixed between their heads, and further secured by diagonals or struts which served the double purpose of fixing the king-posts more securely, and of preventing the arch from springing. The abutments were of solid masonry. The floor or roadway rested upon girders which were laid upon shoulders formed in the sides of the king-posts, and securely bolted to them. Tie-beams extended across the roof of the bridge from the heads of the opposite king-posts, by which these important timbers were yet more entirely secured, serving at the same time to support the roof, which was of light construction. The sides of the bridge were closely boarded in.

The timber employed in the construction of bridges requires to be regarded in a different manner from that used in more solid structures, since in the former case it is subjected to many varieties of strain, the strain being irregular. The passage of carriages produces a constant vibration, and this vibration, although communicated to the entire bridge, is yet more severely felt in the part immediately influenced. The natural elasticity of timber causes it to bend to a certain extent under a passing load, and to recover itself after the load has passed; but this constant action is prejudicial to the elasticity and flexibility of the material. For this reason, every precaution must be adopted to render the framing as rigid as possible, and by a frequent and proper application of paint, pitch, or other material, the destructive effects of the alternations of dryness and humidity should be prevented.

In selecting timber for engineering purposes, it must be borne in mind, that although in the growing tree the heart is the strongest portion, yet that after the tree has attained maturity, decay commences in the interior, and that, therefore, the exterior portions will generally be found the most reliable. Above all things the least sign of decay in a piece of timber must be eradicated. Too much care cannot be used in this respect, for, like a disease, it will spread itself slowly but surely throughout the entire piece, and will even communicate the destructive action to adjoining pieces.

The choice of the timber for a structure must depend very largely upon local considerations, as the cost of carriage will often preclude the employment of the most suitable kind. Amongst those kinds which are of the greatest value to engineering structures, the oak and the fir rank highest. The former from its hardness is difficult and expensive to work, but its great durability renders the first cost a matter of less moment. In submarine structures especially, the advantage of employing oak is apparent, as it will endure under water for an unknown period. There are several kinds of oak, and its specific gravity varies according to the soil in which it grows. Its strength is proportionate to its density, and that timber is the most durable whose density is the highest; but the density being chiefly due to the length of time occupied in the production of the wood, it follows, that the colder the soil, and therefore the slower the growth of the tree, the better is the timber.

The specific gravity of oak varies from 1·000 to 1·054, and its weight per foot cube from 70 to 74 lbs. When properly seasoned, the weight will become reduced from 60 to 63 lbs. It may be yet further reduced by drying, but it is found undesirable to push this too far, and as a general rule it is in its best condition for the purposes of building when it has lost about one-sixth of its original weight.

The expensive character and limited quantity of good oak renders it desirable to find a substitute, and in no timber have we a better, all things being considered, than good sound fir. The best fir timber is obtained from the Baltic coasts, and its lightness and stiffness render it very desirable for girders and framing generally. The same rules with regard to quality hold good in the case of fir as of oak—slowness of growth; and this slowness is best ascertained from the annular rings, which should be thin and close together. The trees are usually sawn up into deals of three inches thick, but they may be had in the bulk as thick as 12 inches.

Timber for engineering purposes should be cut at the fall of the year, that is, when the sap has retired from it; and it should not be used until after at least six months' constant exposure either to wet or dryness, and the bark should have been removed three months before using. The principal strain and thrust should always be thrown upon the end grain of the wood.

The weight that will break a piece of timber must be ascertained before we can find the load it ought in practice to have placed on it; and as a safe rule, the deflection of a beam supporting a lateral weight should never be allowed to extend beyond $\frac{1}{480}$th part of its length, or $\frac{1}{40}$th of an inch to a foot of length.

It is most desirable in employing timber for any structure, but more especially for a bridge, to ascertain the direction and amount of strain it will be subjected to. The *parallelogram of forces* becomes one of the most valuable rules for the guidance of the engineer in all structures consisting of beams. This remarkable law, which governs the equilibrium of any three forces of whatever kind, may be stated as follows:—*If three forces acting upon a point are in equilibrium, and lines be measured from this point in the directions of the forces, so as to contain each a given unit of length as many times as there are units in each force, then these lines will form the adjacent sides and diagonal of a parallelogram.*

From the point A (Fig. 64) let the two lines A B, A C be drawn, of which A B shall consist of five units of length, and A C of ten such units, the lengths representing the amount of force applied; complete the parallelogram A B D C; then the diagonal A D represents the *direction*, and its length the *amount* of strain exercised by A B and A C at the point A.

From this law it follows, that whatever be the number of forces acting upon the point A, we may replace any one of them, A D, by two, A B and A C, into which it is resolved; and conversely, we may replace any two of them, A B and A C, by their resultant A D; and further, when we know the directions of the three forces which hold a point at rest, and the magni-

tude of one of them, we can determine the magnitudes of the other two forces.

Rectangles have their centres of gravity at the intersection of the perpendiculars let fall from the middle of adjacent sides; a piece of timber 10×10 contains in its section 100 square inches, and its centre of gravity will be five inches from each side. If the piece be broken by a lateral force, its fracture will terminate at the *upper* surface, or five inches above its centre of gravity. The area $100 \times 5 = 500$ gives us its lateral strength. This may be regarded as a rule with respect to lateral thrust. For instance, if the above piece of timber be sawn through the middle of its length, we obtain two pieces 10×5 giving each a section of 50. Multiply this by 5, which is the distance of the centre of gravity from the *top* side, and we obtain 250, or half the lateral strength the beam previously possessed. But now turn the same half beam on its flat side. Then 50, its sectional area multiplied by 2·5, the distance of the centre of gravity from its *upper* surface, and we obtain only 125, or just one-half the lateral strength the beam possessed when laid on its edge. From this fact we learn the value of placing timbers, such as flooring joists, upon their edges, in order to utilise to the utmost their strength. It will be seen also by the above that timbers possessing the greatest section may, by an unwise application, be of less absolute value, as regards the work they have to do, than timber of less scantling properly applied, affording another instance of waste of material. Thus, a piece of timber 8×6 has an area of 48 inches, and a piece 7×7 contains 49 inches; but the strength of the former placed on its edge is $8 \times 6 \times 4 = 192$, whilst that of the latter is $7 \times 7 \times 3{\cdot}5 = 171{\cdot}5$ only. From the same rule, we learn that a piece of timber whose cross-section is that of an equilateral triangle is, when subjected to lateral thrust, twice as strong when resting on its base as when placed on edge, because the centre of gravity is only $\frac{1}{3}$ of its height measured from its base, but $\frac{2}{3}$ from its apex. In a cylindrical beam the lateral strength is as the cube of the diameter. A piece of timber of the greatest strength that can be cut out of a round tree is obtained by dividing the diameter of its section (see Fig. 65) into three equal parts, A, B, C, raising perpendiculars upon these points to the circumference, and uniting the points of intersection by the lines D E, E F, F G, G D. The rectangle so obtained will form the strongest beam obtainable from the tree.

If a beam be supported at one end only, and loaded at the other, the weight so placed exercises four times the amount of strain it would supposing it were suspended in the middle and the beam supported at both ends, and a weight uniformly distributed over a beam exercises a tendency to break it, of only one-half of what it would if concentrated in the middle.

Suppose S to represent the weight requisite to break a piece of timber whose length, breadth, and depth are each 1 inch, and let l represent the length of some other beam of a similar wood in inches, b = its breadth, d = its depth, and W the weight that would break it; then if a beam be fixed at one end, and loaded at the other, $W = \frac{s\,b\,d^2}{l}$; if the beam be fixed at one end, and loaded uniformly throughout, $W = \frac{2\,s\,b\,d^2}{l}$.

If a beam be supported at each end, and loaded in the middle, $W = \frac{4\,s\,b\,d^2}{l}$; or if a beam be supported at each end, and loaded uniformly throughout, $W = \frac{8\,s\,b\,d^2}{l}$; and if a beam be fixed at one end and loaded in the middle, $W = \frac{6\,s\,b\,d^2}{l}$. These formulæ become of value when the cohesive strength of various kinds of timber has been determined. We give a few in the following table, the value having reference to a cube of one inch:—

Beech	1,556	Fir, Memel	1,635
Chestnut	1,350	„ Norway	2,376
Elm	1,620	„ Scotch	1,746
Ash	2,355	„ Larch	1,896
Oak	1,672	Mahogany:—	
Teak	2,151	„ Spanish	1,275
Fir, Riga	1,590	„ Honduras	1,911

To apply the formulæ given, to the table of values, suppose it to be required to ascertain the breaking strain of a beam of Norway fir 10 feet long and 10 inches square, supported at both ends, and the weight uniformly distributed; then $W = \frac{8 \times 2376 \times 10 \times 10^2}{120} = 158{,}400$ lbs.; or if the weight be applied to the beam in the middle only, $W = \frac{4 \times 2376 \times 10 \times 10^2}{120} = 79{,}200$ lbs. By the same rule, a beam of Scotch fir will support respectively only 116,400 lbs., and 58,200 lbs. under similar conditions to the above.

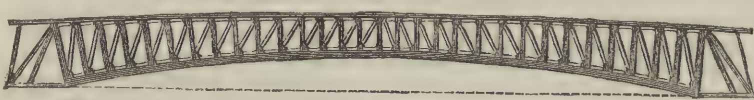


Fig. 63.

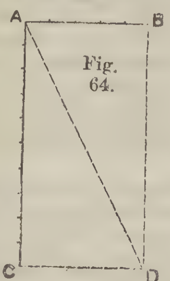


Fig. 64.


Fig. 67.

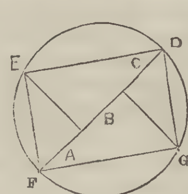


Fig. 65.

Fig. 69.

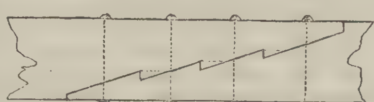


Fig. 68.


Fig. 70.

It is a safe rule to adopt, not to load a piece of timber beyond one-fourth of its breaking strain.

The resistance to compression in the direction of the length of a piece of timber is not always equal to the power that would tear it asunder. Timber with a cross-grained fibre, such as oak, offers less resistance to compression than timber with a straight grain; hence, a fir-post is capable of supporting three times as great a weight as one of oak, although, as a tie, oak will be the strongest. The relative strength of timber against compression is as the cube of its diameter directly, and inversely as the square of its length. The stiffest post is that whose sides are to one another in the proportion of 10 to 6.

The length of a post is a matter of more moment than might at first sight appear, even though the weight be applied on the end, and the beam stand perfectly vertical. Experience has shown that if a vertical post be more than seven or eight times the width of its base, it will bend under the weight applied before it will crush. Both oak and fir beams become diminished in strength when their length is such that they will bend rather than crush. Rondelet ascertained by experiment that the mean strength of oak for supporting a weight was 47·52 lbs. avoirdupois for a cube of $\frac{888}{1000}$ of an inch: and if we take the strength of a cube of 1 = 1, the strength of a post whose height is 12 times its base = $\frac{5}{6}$; one of 24 times = $\frac{1}{2}$; one of 36 times = $\frac{1}{3}$; one of 48 times = $\frac{1}{6}$; one of 60 times = $\frac{1}{12}$; and one of 72 times = $\frac{1}{24}$. These are important considerations in the arrangement of beams, and it leads to the conclusion that no beam unsupported laterally should be greater in height or length than about 10 times its diameter at the base, supposing the force be applied as a thrust at the extremity.

When a beam becomes inclined from the perpendicular, its strength to support a weight applied vertically diminishes in proportion to its angle of inclination. Let A B (Fig. 66) be a beam standing vertically at B, then suppose it inclined in the

direction C B; let fall the perpendicular C b; then the weight applied vertically at C which C B can support will = C b = the sine of the angle of inclination. As C moves towards A, the length of C b will increase, and at A will = the radius. Hence the rule, that the strength of a piece of timber standing vertically, is to that of a piece of the same dimensions inclined as A B to C b, or as the radius to the sine of the angle of inclination.

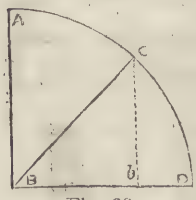


Fig. 66.

Owing to the difficulty of obtaining beams of great length, such as are constantly required for bridge-work, it is necessary to adopt some method of uniting them firmly at their extremities, so as to resist every kind of strain which may be applied. This joining process is termed *scarfing*.

The simplest joint is that known as *ship-lapping* (Fig. 67), in which each end is cut down through half its thickness, and the cut met by a cross-cut, and the piece removed. The two ends being similarly cut will unite with a flush-joint, and are secured by trenails or bolts. This makes a neat joint, but it will not bear a strain, only a thrust.

An ordinary scarf is shown in Fig. 68, and consists in cutting notches in the inclined surface given to the ends of each beam, so that they shall fit into each other; their connection being retained by two or more bolts. Such a joint will sustain an amount of strain equal to the actual crushing strength of the timber contained in the notches, and bounded by the horizontal dotted lines, supposing the grain of the wood to run with the length of the scarf.

Another form of scarf is shown in Fig. 69, in which a joggle of hard wood, A, is driven into the centre of the scarf, the ends of which are dovetailed. Such a joint is not altogether dependent upon a bolt driven through, as in the preceding, but is improved by a band of hoop iron placed around it.

The length to be given to a scarf must depend upon the cohesive force of the timber. A safe rule is to make that from oak, ash, or elm, six times the depth of the timber; and that for fir, twelve times the depth.

When timbers have to be united at an angle—as, for instance, in the union of the principal rafter with a tie-beam (Fig. 70)—the lower beam should be notched as shown, and the end of the rafter cut to correspond. A bolt passed through both will keep it in its place, and as the thrust is always in the same direction—namely, against the notch—it cannot move. The character of the notch and corresponding cut may be varied.

Much more might be said respecting timber, but a further consideration of the subject belongs rather to carpentry than engineering, and we refer our readers to "Building Construction" and the early papers in "Technical Drawing" for further information. One general remark is, however, necessary, and that is, that as all timber is liable to expansion and contraction, care must be taken in making joints to allow for this.

SEATS OF INDUSTRY.—XXXVII.

BOMBAY.

BY WILLIAM WATT WEBSTER.

THE most important centre of commerce in our Indian empire certainly deserves a place in this series of papers, not only on account of the intrinsic interest attaching to its history, but also because it fairly illustrates what British trading enterprise has accomplished in other Eastern towns. Bombay stands on an island of the same name, which was formerly separated into several smaller islands, but many acres of land once under water have been recovered, and the two ranges of hills that cross it have been united by fertile valleys. It is the capital of the Presidency of Bombay, which has an area of 137,743 square miles, and a population estimated at over 20,000,000. The city is very advantageously situated for the prosecution of commerce, but the greater part of the site on which it is built is low-lying and swampy, and previous to the construction of an expensive system of drains and embankments, it was very unhealthy.

It is not necessary to our purpose to trace the history of Bombay farther back than the year 1530, when it was transferred to the Portuguese by an Indian potentate. In 1661 the Portuguese ceded the island to Charles II. as part of the dowry of Queen Catherine; but the Portuguese governor having refused to deliver it up, it had to be besieged with heavy loss before it came into actual possession of the English in 1664. It is very curious to note what was thought of this new acquisition by the English politicians of the time, who, if we may judge from an entry in Pepys' "Diary," scarcely considered it worth having. "It seems strange to me," he writes under date 1663, "that such a thing as this, which was expected to be one of the best parts of the Queen's portion, should not be better understood; it being, if we had it, but a poor place, and not really so as was described to our king in the draught of it, but a poor little island; whereas they made the King, and Lord Chancellor, and other learned men about the King, believe that that and other islands that were near to it were all one piece." We need not wonder that Mr. Pepys' failed to foresee the value that this "poor little island" would acquire in the future. In 1668 the city and island were handed over to the East India Company, and at this date the population consisted of about 10,000 natives and a few Portuguese and Englishmen. Bombay was used at first by the East India Company only as a military station, and it was here that the first companies of native troops which formed the nucleus of the famous Sepoy army were trained under English officers. Up till 1686 Surat was the seat of the Indian Government, and the commercial head-quarters of the East India Company, but in that year the Company removed to Bombay. Owing to the protection afforded by the troops, native cotton-spinners, weavers, and merchants, crossed over from the mainland and settled on the island, and the manufacturers of Bombay soon acquired some special privileges. In 1670 Bombay was besieged by the Mogul, who only withdrew in the following year in obedience to the orders of Aurungzebe. Under the government of the East India Company the native population of the island rose in a few years from 10,000 to 60,000, and by the end of the seventeenth century Bombay was the principal centre of English commerce in India, and it has retained its pre-eminence ever since.

From the time of Alexander the Great till the destruction of their strongholds in the Arabian and Persian Gulfs, in 1819, formidable bands of pirates infested the Malabar coast, and the trade of Bombay suffered long from their depredations and the check they gave to enterprise. Plague and rebellion also devastated and disturbed the colony for many years. In 1788 Aurungzebe the Great invaded Bombay, and the East India Company, not then having sufficient forces at command to repel the assault, averted the danger by liberal payments of money to their assailants. But notwithstanding the numerous and great obstacles it had to contend against, Bombay made steady and rapid progress, no small portion of its later prosperity being due to the Parsees, who settled in the city in large numbers, and made it their adopted home. This enterprising race are not only proportionally more numerous in Bombay than in any other town in India, but they constitute a very wealthy and influential section of the community. The greater part of the island belongs to Parsees, and there is scarcely a European house of business in Bombay in which a Parsee has not a share, and in general the Parsee is the largest capitalist. Descendants of the Ghebers, driven out of Persia by Shah Abbas, the Parsees are not less remarkable for the mildness of their manners, than for their intelligence, perseverance, and success in the pursuit of wealth. Although their women enjoy more liberty than the Hindoo and Mahometan women, they are the chastest in India; indeed, it is said, that no woman belonging to the sect has ever been known to be a courtesan. The Parsees provide for their own poor; and although devotedly attached to their religion and customs, they eat, drink, and hold the freest intercourse with Europeans. The whole of the northern quarter of Bombay is occupied by this sect, and in every department of trade connected with the docks and shipping they have the chief interest. It was a Parsee family named Lowji who first introduced ship-building into Bombay in 1735, and the same family has remained at the head of that industry, which is principally carried on at this port by men of the same race, ever since. Not only have vessels for the Indian navy been constructed by Parsees in the ship-building yards of Bombay, but many large imperial men-of-war have also been built there. The country-houses of the wealthy Parsees are furnished with

the richest European decorations, and their owners are famous for their public spirit and the munificence of their benefactions. Among the charitable institutions of Bombay the Jamsetjee Hospital and the Jamsetjee Obstetric Hospital take high rank, and these hospitals were founded and endowed by a member of a Parsee family which is highly honoured in England as well as in India. Indeed, few merchant princes in the world have acquired a higher or more wide-spread reputation for enterprise, integrity, and patriotism than Sir Jamsetjee Jeejeebhoy of Bombay.

In addition to their charity, which seems to be an inherent quality in the Parsees, they exhibit a marked tolerance to the opinions and religious views of others. There are many temples for the adoration of fire in the city, and morning and evening the whole of the male Parsee population betake themselves to the esplanade and worship the sun. In these rites the females take no part, but, as in ancient times, the Parsee women of all ranks continue to carry water from the wells. Among the strange customs of this sect is the exposure of their dead to be devoured by vultures in buildings left open at the top to admit the ravenous birds. Being regarded as aliens both by Hindoos and Mahometans, and being enthusiastic traders, the Parsees have all along been favourable to the English power, and from the earliest times they have proved themselves valuable and reliable auxiliaries.

THE LATHE.—XIV.

By Henry Northcott.

SELF-ACTING LATHES (*continued*).

The overhead shaft carries a coned pulley for driving the lathe-pulley, and two sets of three or altogether six other pulleys. But one set of pulleys is of much smaller diameter than the other. When the lathe-spindle is in motion and geared with the leading screw so as to drive the slide-rest along the lathe-bed, the traverse of the tool is usually slow, and if the lathe be employed in cutting a screw with a right-handed thread, the direction of the traverse will be towards the cone headstock; that is to say, when the lathe is employed upon its ordinary work of plain cylinder turning and right-hand screw-cutting, the tool is caused to travel along the work from right to left, or from the screw headstock to the cone headstock. When the tool has travelled to the end of its cut, the slide-rest has to be run back again towards the right, in order that another cut may be commenced. For plain cylindrical turning the practice is to run the slide-rest back by means of the large traverse handle in front, first of all slightly withdrawing the tool from the work, so that its point may not scratch against the surface, and also unclasping the nut from the leading screw. All this is done without stopping the lathe. But when the lathe is employed in screw-cutting the tool runs faster, and if the screw be short, it is not worth while to run back the rest by hand, as by reversing the lathe the saddle is run back by the screw almost as fast. For long screws there would be a saving of time by using the hand-traverse motion, were it not for a practical difficulty in getting the tool to start always from the right place. Owing to this difficulty, it is generally preferable to run the tool back by reversing the lathe rather than to run it back by hand, even though a little more time be occupied by the journey. The mode in which the overhead or counter-shaft is driven from the main shaft has been explained, and to drive the lathe in the opposite direction to the usual one it is only necessary that the overhead shaft shall be driven from the main shaft by a crossed belt instead of by the straight one. And to have the power of driving the lathe in either direction, there must be both a straight and a crossed belt with provision for shifting either of them on to the fast-pulley of the overhead shaft. This obviously entails the necessity of having two loose-pulleys, and one fast-pulley placed between them. These three pulleys would necessarily be of the same size, and the lathe would be driven at the same speed both forward and backward. In order, therefore, to reduce the time spent in running the tool back, good lathes are frequently furnished with two sets of pulleys of different sizes. The small pulleys are driven by the crossed belt, and the large ones by the straight belt. With this arrangement, the reverse motion of the lathe is much faster than the forward motion, and the tool is consequently run back towards the screw headstock in one-half or one-third the time employed in its forward or cutting journey. A lathe fitted with a quick return motion is enabled to turn out more work, and the hand-traverse saves no time even for the longest screws.

Fig. 102 is a light screw-cutting lathe by Messrs. Whitworth and Co., of Manchester. The leading screw is placed inside the bed, and is driven from the lathe-spindle by the change-wheels seen at the end. This position of the screw is adopted by some machine-tool makers in preference to that of outside the bed, and it has some advantages, but at the same time it introduces complications and inconveniences which render the arrangement anything but an unmixed advantage. The intermediate change-wheels are carried upon studs fastened to a double-slotted plate, radiating round the centre of the leading screw, and hence termed the radial arm. The mode of calculating and arranging these wheels will be hereafter explained, but the function of the radial arm will be apparent from the several illustrations.

A pile of the change-wheels is shown standing behind the lathe, and on the bed is a hand tool-rest, and a very useful instrument called a boring collar. On the ground will be seen the counter-shaft with its pulleys, supporting brackets, and belt-shifting slide; also a small drill chuck, a face-plate, an eight-screw chuck, and a four-jawed chuck. These are all indispensable instruments to a lathe of this sort, the four-jawed chuck being invaluable. Fig. 103 is another excellent specimen of a lathe by Messrs. Fairbairn, Kennedy, and Naylor. This one is both self-acting and screw-cutting, and the automatic mechanism is also applied to the surfacing-slide of the rest. It is always advisable to have the bearings for the spindle as wide apart as possible, as its centrality is not so liable to be affected by wear, and the headstock should be made sufficiently strong to prevent the possibility of any springing or yielding against the pressure to which it is necessarily subjected. The cone-pulley of this lathe has four steps or speeds, and good strong back-gearing. The wheels are thrown into and out of gear by an endway motion of the spindle, upon which the back wheel and pinion are hung. A face-plate is shown in place upon the spindle-nose, whilst the eight-screwed chuck and the driving-plate are lying on the ground in front with the overhead apparatus, which, it will be observed, has the double set of pulleys for getting a quick return of the tool. The position and arrangement of the change-wheels are very clearly shown in this illustration. A small pinion on the end of the lathe-spindle gears into a large wheel in the intermediate stud, and a pinion on the same socket as this wheel gears into a larger wheel placed upon the end of the leading screw. The leading screw would consequently, under this arrangement of wheels, be driven much slower than the spindle itself. So far as the direction of the motion of the leading screw is concerned, a pair of intermediate wheels on the same axle or socket act as one wheel, and a pinion on the lathe-spindle driving a wheel on the leading screw will move the slide-rest from right to left, or in the direction necessary for cutting a right-hand spiral.

Sometimes, however, screws are required to have left-hand spirals, and to produce these the tool must move along the work in the reverse direction, or from left to right. This reversal of the direction of the tool's traverse is brought about by the introduction of a second intermediate wheel between the pinion on the lathe-spindle and the leading-screw wheel. The position and size of this second intermediate is a matter of no consequence, nor does it affect the speed of the leading screw in any way. If, therefore, the wheels be arranged with one intermediate wheel or two on one stud, to give such a number of rotations to the leading screw as will cause the tool to describe a right-handed spiral on the work of, say, one turn to the inch, the introduction of another wheel of any convenient size anywhere into the train of change-wheels will, by reversing the direction in which the leading screw rotates—the direction of the lathe's rotation remaining the same—cause the tool to describe a left-handed spiral of the same pitch as before.

Generally, the second intermediate wheel with its stud forms quite a separate part of the lathe, and it is only attached to the radial arm when the reversed traverse is required, which is not very often. But some lathes are constructed with a reversing wheel placed in position upon a swing-plate, so that it may be thrown into the train by merely raising a handle. This arrangement is convenient in some respects, but its merit is not such as to cause it to be very often adopted.

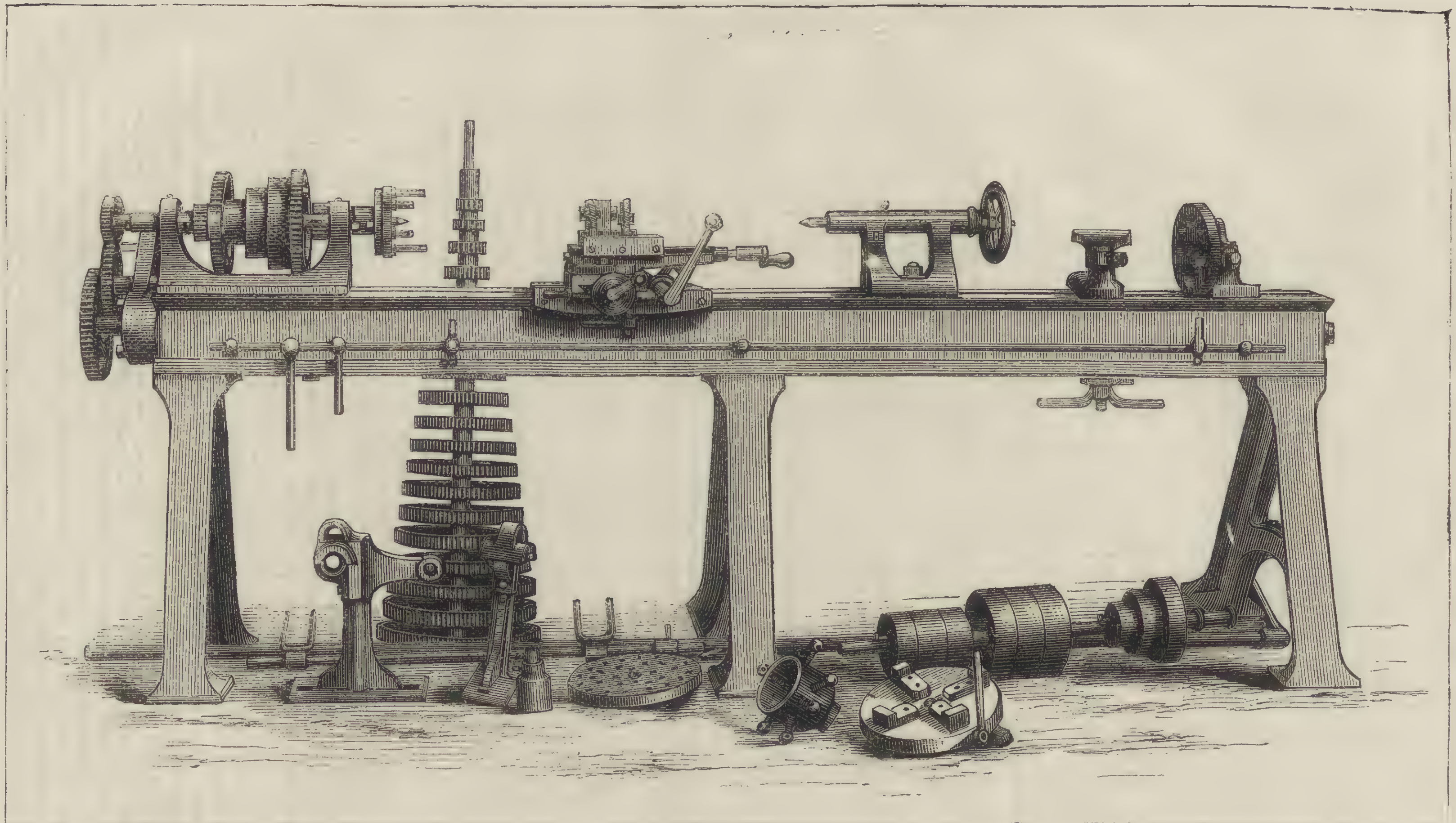


Fig. 102.—LIGHT SCREW-CUTTING LATHE BY MESSRS. WHITWORTH AND CO.

An excellent screw-cutting lathe is made by Messrs. Cunliffe and Croom, of Manchester. This lathe has an outside leading screw, and rather a complicated system of change-wheels, the reversing intermediate wheel being arranged on a swing-plate as just described. The bed is formed with a "break" or gap just under the face-plate. A bridge-piece, however, is furnished to complete the surface of the bed. In lathes the largest article that can be turned is determined by the height of the centres, or distance of the centre of the spindle from the surface of the bed, which is the radius of the largest article the lathe will receive. It is occasionally required, however, to turn or bore articles of larger diameter than it would be convenient to have a special lathe for, and as such articles are mostly short, the adoption of a gap-bed renders the lathe equal to these articles without the necessity of its being too heavy for its ordinary work. When a large wheel, for example, has to be bored or turned, the bridge-piece which is placed across the gap is removed, and the height of the lathe-centres is thereby increased, as the diameter of the largest short article the lathe will receive is then equal to double the distance from the centre of the spindle to the bottom of the gap. Gap-lathes find employment chiefly in small workshops, as they may render large lathes unnecessary; but in establishments where there is enough large and small work to keep large and small lathes fully occupied, gap-beds are not in favour.

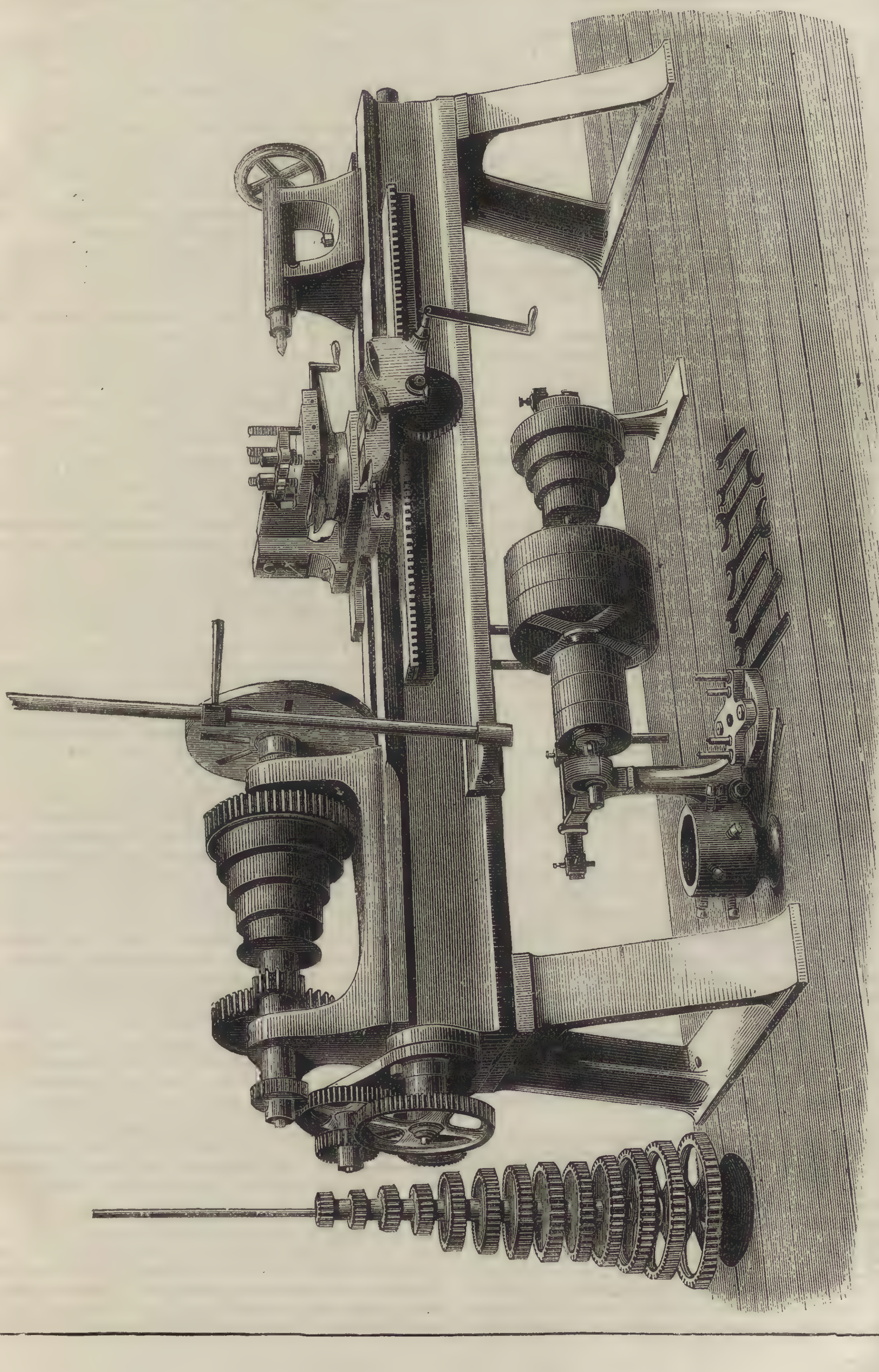


Fig. 103.—SELF-ACTING AND SCREW-CUTTING LATHE BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

TRADE-MARKS.—II.

By A London Barrister.

REMEDIES FOR WRONGFUL USE OR IMITATION.

In our first paper we dealt generally with the nature of trade-marks and the property which can be had in them. A necessary incident of property is that it is liable to invasion; those who have no right to use it are tempted to take the benefit of it in proportion to the undecided nature of it, and the difficulty of repelling or obtaining redress for a trespass. It would be manifest that there must be a preliminary difficulty in all legal proceedings which may be taken with this view in establishing that the particular name or symbol is not *publici juris*. Of course if property in a name or trade-mark be set up it is for the alleged infringers, as in the case of patents, to prove that it is public property. But it is equally clear that any person proposing to institute a suit should know as far as may be what claim he has upon it as an individual, and what right can be set up on the part of the public. The penalty which follows a mistake in this direction is very heavy.

In illustration of these observations, it is merely necessary that we should refer to a case which not very long ago occurred in the Court of Chancery. A suit was instituted to restrain the use of the words "Kalydor" and "Odonto;" but the Court held upon the evidence that these words were *publici juris*, and the plaintiff's bill was dismissed with costs. This at once proves how material it is that any person claiming property in words and signs should be reasonably clear in advance that his right to claim a monopoly is well founded. It is not possible always to be sure that a Court either of Equity or Common Law will take the view which appears to be the right one upon the evidence, and upon this very question courts have differed. For example, in the litigation connected with the famous Glenfield Starch, a Vice-Chancellor considered that there could not be any property in the name "Glenfield," and dismissed a bill filed by Mr. Wotherspoon. This decision was reversed on appeal, the Court above being of opinion that the word "Glenfield" as connected with starch had become the exclusive property of one person. Therefore, with all the care in the world defeat may be possible, and should it be made to appear that the name or symbol in which property is claimed has been used to any extent so as to create a mere show of right of property in another than the claimant, the remedy will be entirely gone.

What the remedy is we will now consider. At law the proper remedy is by an action on the case for deceit, and proof of fraud on the part of the defendant is of the essence of that action. But a Court of Equity will act on the principle of protecting property alone, and it is not necessary for the person applying for the injunction to prove fraud in the defendant, or that the credit of the plaintiff is injured by the sale of an inferior article. The injury done to the plaintiff in his trade by loss of custom is sufficient to support his title to relief. Neither will the plaintiff be deprived of remedy in equity even if it be shown by the defendant that all the persons who bought from him goods bearing the plaintiff's trade-mark were well aware that the goods were not the plaintiff's manufacture. If the goods were so supplied by the defendant for the purpose of being sold again in the market, the injury to the plaintiff is sufficient. Again, it is not necessary for relief in equity that proof should be given of persons having been actually deceived, and having bought goods with the defendant's mark under the belief that they were of the manufacture of the plaintiff, provided that the Court be satisfied that the resemblance is such as would be likely to cause the one mark to be mistaken for the other.

Where a tradesman has adopted a design which happens to resemble the trade-mark of another tradesman, and the adoption has been innocent, the Court, while doing all the justice it can to the originator, will do whatever is consistent with that course to preserve to the second adopter the benefit to be derived from the use of a distinctive symbol. It is very easy to sail near the wind in imitating a label or trade-mark, but an imitation which just avoids an injunction is not to be indulged in, for the Court under such circumstances would refuse to give the defendant any costs. In judging of the facts of any case in which an injunction is sought for, the Court will look at the intention to deceive. Where the description of a manufactured article is in substance retained, and the name of the maker is added to, and there is a general and sufficient imitation to deceive the public, the Court will interfere by injunction.

The general principle is, that the Court will always interfere where there has been a fraudulent use of the name. But the Court must not only be satisfied that the course which has been taken by the defendants was calculated to deceive the public, but that it has been represented to them by the plaintiffs as having that effect; and that, after such representation, the defendants persisted in continuing the use of the name in the same manner. Then, on the plaintiffs bringing the case before the Court, the Court considers itself justified in saying that that which was not fraudulent at first became so by the defendants persisting in the same course, and that therefore the plaintiffs would be entitled to the relief they asked.

If a trade-mark be dishonest, no proceeding can be taken to restrain its general use. The dishonesty must, however, have the effect of a fraud. A good example of an innocent misrepresentation is afforded by the use of the word "patent" in a trade-mark. It might be supposed, at first sight, that to use that word in a trade-mark describing any particular article for which a patent had not been obtained, as described in our papers on that subject, would be a fraud upon the public, and the trade-mark therefore disentitled to protection. But Vice-Chancellor James pointed out, in considering the use of the term "patent thread," that the word "patent" might be so used as not to deceive any one, or cause a belief that the goods so called are protected by a patent. He instanced the case of "patent leather boots;" and speaking of the term "patent thread," he said that it had so long been used in the particular trade that it might be said to have become a word of art.

The general law on the question of dishonesty on the part of a person claiming property in a trade-mark has been very clearly discussed by a learned judge in a recent case. There cannot now be any doubt, it was said, that a trader may be guilty of such misrepresentations with respect to his goods as to amount to a fraud upon the public, and to disentitle him on that ground against a rival trader to the relief in a Court of Equity which he might otherwise claim. What would constitute a misrepresentation of this description may, however, in particular cases be a reasonable subject of doubt. The general rule seems to be that the misstatement of any material fact calculated to deceive the public will be sufficient for the purpose. It was urged that if the principle be pressed to its full extent it will prevent the use of the name of a firm by any but the original partners, and will of course prevent on a transfer of the business the right to use the name by any other persons. The answer given to this was, that the name is understood not to be confined to those who first adopted it, but to extend to and include persons who have afterwards been introduced as partners, or persons to whom the original partners have transferred their business. The name of the firm continues to be used in many cases long after all the original traders have died, or ceased to have any interest in the concern, as in the great banking houses of Child and Coutts, and many other mercantile houses. If a manufacturing house use the name of a firm, and stamp the name of its firm upon its goods, though the name of the firm no longer represents the same persons as at first, it is no fraud upon the public for the reasons already alluded to. For the same reason, the use of the whole trade-mark of the firm by the new partners or their successors, if the term "trade-mark" be understood in what has been already said to be its proper sense, is no fraud upon the public; it is only a statement that the goods are the goods of the firm whose trade-mark they bear. But trade-marks, or what are called such, may go much further than this, and contain statements materially affecting the value of the goods to which they are affixed. In such cases they must be judged of like statements made in separate labels or advertisements. The question will be, are such statements true? And if not, are they misstatements of material facts, and calculated to impose upon the public? If a trade-mark represents an article as protected by a patent, when, in fact, it is not so protected, it seems that such a statement *primâ facie* amounts to a misrepresentation of an important fact, which would disentitle the owner of the trade-mark to relief in a Court of Equity against any one who pirated it. What the issues in a case of alleged piracy or imitation will be, well appears from the case of Crawshay *v.* Thompson. That was an action for wrong-

fully, knowingly, and fraudulently stamping bars of iron made by the defendants with a stamp resembling one used by the plaintiff, which the defendants knew and intended to be in imitation of the plaintiff's, and which was used by the defendants in order to denote that their iron was made by the plaintiff; and for knowingly selling the iron so marked as and for the plaintiff's iron. A correspondence between the parties was given in evidence, in which the plaintiff urged that the use of the mark by the defendants was a fraud upon him. The defendants, in answer, asserted that they had used the mark for many years continuously. This was not so in fact; but it was shown that the mark had been adopted by them in the execution of orders received from foreign correspondents. It was held that it was properly left to the jury to say whether the defendants' mark bore such a close resemblance to the plaintiff's as was calculated to deceive the unwary and injure the sale of the plaintiff's goods; and, secondly, whether the defendants used the mark with the intention of supplanting the plaintiff, or whether it was done in the ordinary course of business in execution of orders. In the same case it was ruled that the notice of the resemblance of the mark, given by the plaintiff to the defendants, did not, in the absence of proof of any intention to imitate it on the part of the defendants, give the plaintiff any cause of action.

Having considered the general position of the immediate parties before a Court of Law or Equity, we will go on to discuss the liabilities of persons having forged trade-marks in their possession, and afterwards we will see what are the criminal liabilities of forgers. In a case decided last year, a Court of Equity said that a person having in his hands or under his control goods bearing a forged trade-mark is bound, upon the facts being brought to his knowledge, at once to submit to do whatever he might be compelled to do upon bill filed; otherwise, however innocently the goods may have come to him, he will be liable for the costs of a suit instituted by the person whose right is infringed for the purpose of obtaining relief. The Court went so far as to say that it did not make any difference whether the goods are sent to a person who does not deal in the article consigned, and whose duty is simply to distribute the goods to other persons, or whether the goods are sent to him as consignee for his own purposes. It will not do for him to say, "I do not know anything about the goods sent. I do not know if they have any, and if any, what brand on them or whose it is." It is his duty to know this; and if he receives notice that they bear a fraudulent imitation of another man's brand, he ought to ascertain this as speedily as possible after such notice, and to take the proper and necessary steps to prevent their being disposed of in that state. It may be that without notice, he does not know that the trade-mark, when he sees it, belongs to another; and if so, he may deal with the goods innocently; but as soon as he is informed of the fact, he should act at once, so as not to be in any event, either from wilful or from accidental ignorance, made a party to a fraud committed by another.

In a case tried at law it was alleged that the plaintiff agreed with the defendant to manufacture for him firebricks, to be marked as he should direct; that he directed that they should be marked with R.'s name, he well knowing that R. manufactured firebricks marked with that name to indicate that they were manufactured by him; that the plaintiff, ignorant of the manufacture of firebricks by R., and that marking firebricks according to the directions of R. would be wrongful, manufactured firebricks for the defendant, and marked them with the name of R.; that R. filed a bill in Chancery for an injunction and account against the plaintiff; and that the plaintiff, in order to compromise the suit, paid R. a sum of money. It was held that this complaint disclosed two grounds of action; first, because the plaintiff was liable to the injunction, although he used the trade-mark of R. innocently; and, secondly, because the natural consequence of the defendant's act was to involve the plaintiff in a Chancery suit, even if he had the means of defending it, by reason of his having used the trade-mark of R. innocently.

Before noticing, in conclusion, the criminal responsibility of those who forge and otherwise act dishonestly by trade-marks, we may notice that by the recent Statute 25 and 26 Vict., c. 88, a limited warranty is declared to be implied upon sale transactions of goods in two cases. First, when any person sells or contracts to sell any chattel or article "with any trade-mark thereon, or upon any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing together with which such chattel or article shall be sold or contracted to be sold," the sale or contract shall be deemed to have been made with a warranty that such trade-mark was genuine and true, and not wrongfully used, unless the contrary be expressed in some writings signed by or on behalf of the vendor, and delivered to and accepted by the vendee. Secondly, when any person sells or contracts to sell any chattel or article, "upon which, or upon any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing together with which such chattel or article shall be sold or contracted to be sold, any description, statement, or other indication of or respecting the number, quantity, measure, or weight of such chattel or article, or of the place or country in which such chattel or article shall have been made, manufactured, or produced," the sale or contract shall be deemed to have been made with a warranty that no such description, statement, or indication was in any material respect false or untrue, unless the contrary be expressed in a writing signed, delivered, and accepted as under the preceding provision. The principal penal provisions of this statute enact that every person who, with intent to defraud or to enable another to defraud any person, shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing in, on, or with which any chattel or article shall be intended to be sold, or shall be sold or uttered or exposed for sale, or intended for any purpose of trade or manufacture, or shall enclose or place any chattel or article, or cause or procure any chattel or article to be enclosed or placed, in, upon, under, or with any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing to which any trade-mark shall have been falsely applied, or to which any forged or counterfeited trade-mark shall have been applied, or shall apply or attach, or cause or procure to be applied or attached, to any chattel or article, any case, cover, reel, ticket, label, or other thing to which any trade-mark shall have been falsely applied, or to which any forged or counterfeited trade-mark shall have been applied, or shall enclose, place, or attach any chattel or article, or cause or procure any chattel or article to be enclosed, placed, or attached, in, upon, under, with or to any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing having thereon any trade-mark of any other person, shall be guilty of a misdemeanor, and every person so committing a misdemeanor shall also forfeit to Her Majesty every such chattel and article, and also every such cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing as aforesaid in the possession or power of such person; and every other similar cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing made to be used in like manner as aforesaid, and every instrument in the possession or power of such person, and by means of which any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall have been applied, and also every instrument in the possession or power of such person for applying any such trade-mark or forged or counterfeit trade-mark as aforesaid, shall be forfeited to Her Majesty; and the Court before which any such misdemeanor shall be tried may order such forfeited articles as aforesaid to be destroyed or otherwise disposed of as such Court shall think fit. Further, every person who, with intent to defraud, or to enable another to defraud any person, shall forge or counterfeit, or cause or procure to be forged or counterfeited, any trade-mark, or shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any chattel or article not being the manufacture, workmanship, production, or merchandise of any person denoted or intended to be denoted by such trade-mark, or denoted or intended to be denoted by such forged or counterfeited trade-mark, or not being the manufacture, workman ship, production, or merchandise of any person whose trade-mark shall be so forged or counterfeited, or shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any chattel or article, not being the particular or peculiar description of manufacture, workmanship, production, or merchandise denoted or intended to be denoted by such trade-mark, or by such forged or counterfeited trade-mark, shall be guilty of a misdemeanor, and every person so

committing a misdemeanor shall also forfeit to Her Majesty every chattel and article belonging to such person to which he shall have so unlawfully applied, or caused or procured to be applied, any such trade-mark or forged or counterfeited trade-mark as aforesaid, and every instrument in the possession or power of such person, and by means of which any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall have been so applied, and every instrument in the possession or power of such person for applying any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall be forfeited to Her Majesty; and the Court before which any such misdemeanor shall be tried, may order such forfeited articles as aforesaid to be destroyed or otherwise disposed of as such Court shall think fit.

In proceedings which may be taken under this Act, it will be sufficient to state the mark to be a "trade-mark" or a "forged or counterfeited trade-mark," without further description or setting forth any copy or fac-simile thereof. By section 11, a conviction is not to affect any right or civil remedy which any party aggrieved by the offence may be entitled to; but compulsory evidence given by the offender is not to be admitted against him. By section 12, an intent to defraud, etc., any particular person need not be alleged in any information, conviction, etc., or proved. By section 15, penalties or sums of money forfeited may be recovered by action of debt in any Court of Record, or instead "by a summary proceeding before two justices of the peace having jurisdiction in the county or place where the party offending shall reside or have any place of business, or in the county or place in which the offence shall have been committed."

The seller of the article bearing a forged trade-mark is by section 6 of this Act bound upon demand in writing delivered to him or left for him at his last-known dwelling-house, or at the place of sale, or exposure for sale, by or on behalf of any person whose trade-mark shall have been forged or counterfeited, or used without lawful authority or excuse, to give to the person requiring the same, or his attorney or agent, within forty-eight hours after such demand, full information in writing of the name and address of the person from whom he shall have purchased or obtained such chattel or article, and of the time when he obtained the same.

This entirely exhausts the law relating to the rights and remedies of persons having trade-marks, and the liabilities of persons who infringe such rights.

TECHNICAL DRAWING.—XCI.

DRAWING FOR METAL-PLATE WORKERS (*continued*).

To describe the form of a "tapering piece" of piping, to join two pieces of piping, which are both vertical, but not in the same axis, and which are of different diameters.

Let A B C D (Fig. 663) be a portion of the one pipe, and E F G H the other.

Join B E and C F, and produce the lines until they meet in O; then if O C be produced until it is equal to O B—viz., to I—and I B be joined, it will be evident that O I B is the elevation of a cone placed obliquely on the lower cylinder, and which is cut off at B C, E F.

Now draw any diameter to the cylinder, as J K, and on it describe a semicircle, representing half of the section of the cylinder.

Divide this semicircle into any number of equal parts—viz., L, M, N, P, Q.

Through these points draw perpendiculars cutting the line B C in *l*, *m*, *n*, *p*, *q*; and from *l*, *m*, *n*, *p*, *q* draw lines to O.

Now from O, with radius O *n* (Fig. 663), describe an arc, N′ N″ (Fig. 664), and on this arc set off the lengths into which the semicircle is divided.

From O draw radii through all these points, producing them beyond the arc N′ N″.

From O as a centre, and with O B, O *l*, O *m*, O *p*, O *q*, and O C as radii, describe arcs cutting the radii in Fig. 664 in *q*′, *p*′, *n*′, *m*′, *l*′, and B′, etc., and the curve being drawn through these points will give the bottom of the tapering piece.

The upper curve is to be drawn in the same manner, and will be understood from the diagram.

ROOFS AND DOMES, AND THE METHOD OF COVERING THEM.

Although the whole subject of the development of prisms has been treated of in "Projection," it is deemed desirable to enlarge on the subject here in order to show the application of these studies to the zinc-worker and plumber.

This branch of the subject is most important to plumbers and zinc-men, and therefore the general method of projecting roofs is repeated from "Drawing for Carpenters and Joiners," so that subsequent lessons may be engrafted on it.

Fig. 665.—In this example *a b c d* is the plan of a building to be covered by a hipped roof.

To draw the plan of the roof.

Bisect the angles of the parallelogram, and the bisectors meeting in *e* and *f* will form the plans of the hip-line, and the line joining *e* and *f* will be the plan of the ridge.

Let it now be required to project the elevation from this plan.

Draw any horizontal, as A B (Fig. 666), and perpendiculars from *c*, *e*, *f*, *d*, cutting A B in *g*, *h*, *i*, *j*, and produce *h* and *i* indefinitely. Produce the perpendicular at *c* until it reaches *l*; then it will be clear that *k l* is the width of the roof-trusses (at *k l* and *m n*), which would be at right angles to *a b* and *c d*.

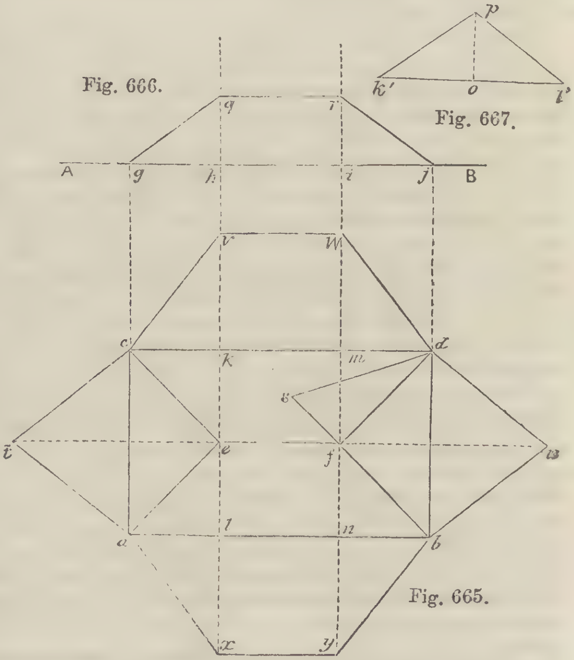


Fig. 666. Fig. 667. Fig. 665.

Draw *k*′ *l*′ (Fig. 667) equal to *k l* in Fig. 665, and at the middle point, *o*, draw the perpendicular *o p* equal to the real height of the truss, which is, of course, a matter dependent on the taste or defined purpose of the architect. This triangle will then be the shape of the truss at this point, and is the section *across* the roof.

Make *h q* and *i r* in Fig. 666 equal to *o p* in Fig. 667. Draw *g q*, *q r*, and *r j*, which will complete the elevation, and this will also be the longitudinal section through the ridge.

We now have to determine the real length of the hip. To do this, draw *f s* (Fig. 665) equal to *o p* (Fig. 667), and at right angles to *f d*.

Join *d s*, then the right-angled triangle *d f s* is the true shape of the hip-truss. This will be understood by cutting a piece of cardboard of the shape described, and placing it on its edge, *d f*. Then it will be seen that *d s* will be the length of the hip.

To develop the covering of this roof—a matter of the greatest importance to the plumber and zinc-worker.

It will be, of course, understood that the surface will consist of four planes, which will meet at the hip-lines.

Now it has already been shown that the ends are triangles, of which *a e c* and *b f d* are the plans; the length of lines *a c* and

$b\ d$ remains unaltered, but the real length of $c\ e$, $a\ e$, $b\ f$, $d\ f$, has been proved to be $d\ s$.

Therefore on $d\ b$ and $a\ c$ construct isosceles triangles, having $d\ s$ for the two remaining sides; these triangles, then, $a\ t\ c$ and $b\ n\ d$, are *the true shape of the coverings of the ends of the roof.*

Now from c and d, with radius $c\ t$, describe arcs cutting the perpendiculars k and m in v and w. Join $d\ w$, $v\ c$, and $w\ v$. Then the trapezoid $c\ v\ w\ d$ is the development of one of the planes forming the side of the roof-covering.

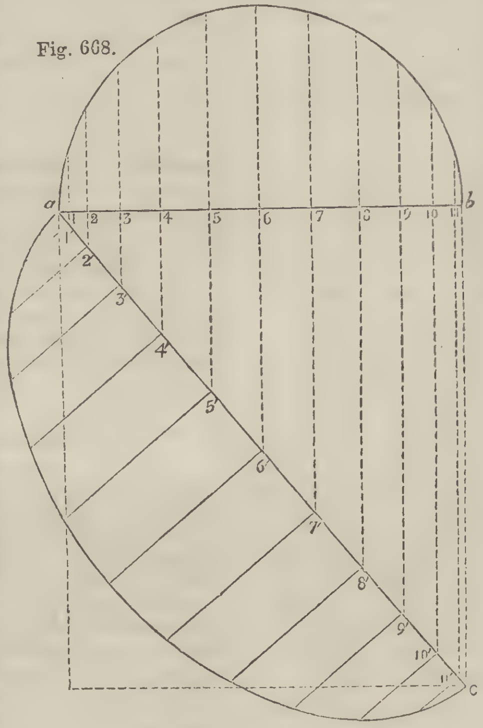
The same length set off on the perpendiculars l, n will give the points x, y, which will complete the fourth plane.

We will now proceed to find the form of the hip when the roof is a groined one.

It will be clear that if a spectator stands on the platform of a railway at the side of a semi-circular arch by which a road is carried over it, he will then see that, whilst the face or elevation of the arch, where it crosses the railway at right angles, is semicircular, its span being of course the diameter of the circle, of which it is half; the length from the springing near which he is standing, to the most distant springing (that is, the one on the opposite of the line at the other end of the arch), will be much longer; yet the arch there is not any higher, although its span, thus taken crosswise, is longer, because the diagonal of a square or other rectangle is longer than any one of its sides.

The principle on which to find the curve that would reach to the springing at which the student is standing to the one referred to, is also shown in Fig. 668.

Fig. 668.



On $a\ b$ describe a semicircle, and from the points 1′, 2′, 3′, 4′ erect perpendiculars cutting the semicircle in 1, 2, 3, 4, or mark off *any* divisions in the semicircle, and from them draw perpendiculars to $a\ b$. Now from the points where the lines 1′, 2′, 3, 4′, etc., cut $a\ c$ draw lines perpendicular to $a\ c$; make each of these equal in height to those correspondingly lettered in the semicircle, and the curve drawn through their extremities will be the form required.

This study has already been fully worked out at Fig. 86 in "Technical Drawing," to which the student is referred.

It is, however, desirable for the continuity of the present branch of our subject that we should in this place repeat Fig. 86 and its elucidation, desiring as we do that each section of our papers on "Technical Drawing" should as far as possible be complete in itself; and as the business of the zinc-worker and the plumber are so intimately associated with that of the building trades, the lesson herein given forms a necessary step in the present course.

Fig. 669.—Here A B C D is the plan of a building to be covered by a groined roof. The arch, the spring of which is A C and B D, is a semi-cylinder. The arch which has its springing in A B and C D, being of the same height but of wider span, is a semi-cylindroid.

A *cylindroid* is a solid body of the character of a cylinder; but whilst in a cylinder all sections taken at right angles to the axis are circles, in the cylindroid all such sections are ellipses. It is, in fact, a *flattened cylinder.* The curve of the groin then is generated by the penetration of a cylindroid and cylinder.

On A B describe the semicircle which represents the face of the arch at the ends A B and C D, and divide it into any number of equal parts, a, b, c, etc.

It is only necessary to use the *quadrant*, as throughout the working the measurements are the same on each side. Draw the diagonals A D and B C.

Fig. 663.

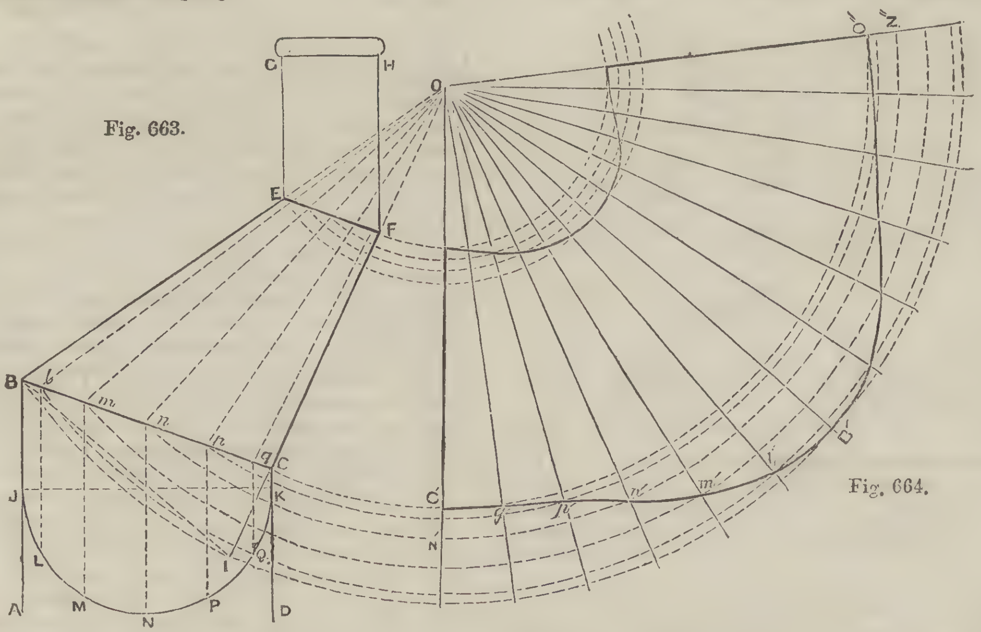


Fig. 664.

From a, b, c, d, e, f draw lines perpendicular to A B cutting the diagonal A D in a', b', c', d', e', f', and set off the same distances on the other half of the diagonal.

From these points draw lines at right angles to A C, and passing through it in points 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11. Mark off on the perpendicular 6 the height 6 f, equal to the

height of the semicircle *f;* and on the perpendiculars 5, 4, 3, 2, 1 mark off in succession the heights of the perpendiculars *e, d, c, b, a,* as contained between the semicircle and its diameter A B. Set off the same heights on the corresponding perpendiculars on the other side of 6 *f*, and the curve traced through these points will be a semi-ellipse, which is the section of the semi-cylindroid forming the arch, of which A C and B D are the springings.

We now proceed to find the curve of the groin; and it will be evident that although the span is still further increased in length, the heights of the different points in the curve will be

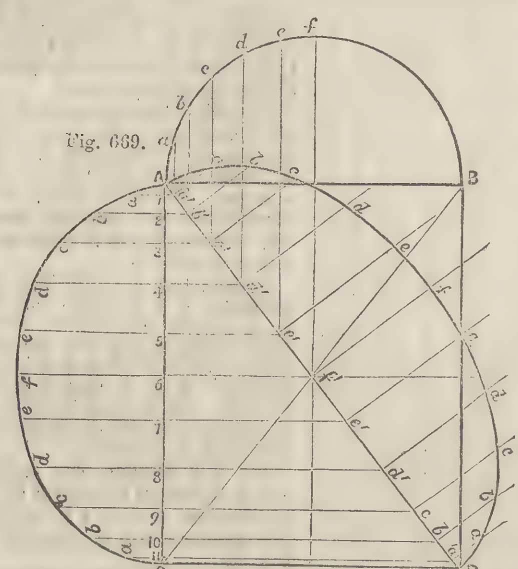


Fig. 669.

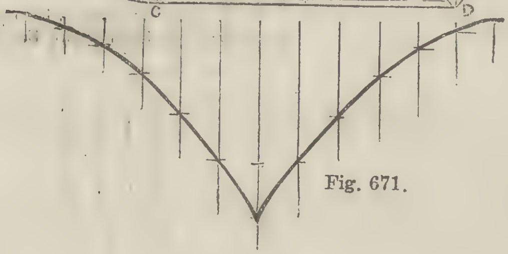
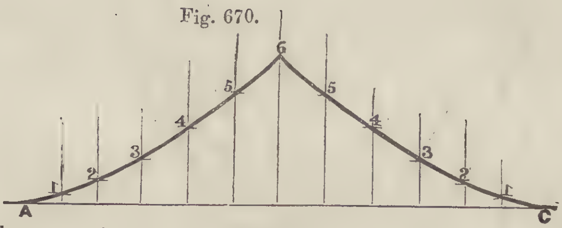


Fig. 671.

Fig. 670.



the same as in both the previous elevations. The span then of the arch at the groin is the diagonal A D (or B C) to which the divisions *a, b, c, d, e, f* have already been transferred from the semicircle, and from these the lines were carried at right angles to A C, on which the height of the points in the curve were set off.

These points—viz., *a′, b′, c′, d′, e′, f′*—in the diagonal, then, will be seen to be common to both arches, since they are the plans of the points in the roof where the cylindrical and cylindroidal bodies penetrate each other. At these points, therefore, draw lines perpendicular to the *diagonal*, and mark off on these the heights of the perpendiculars in the semicircle from which the points on which they stand were deduced. These extremities being connected, the curve so traced is the groin curve, and will give the shape for the centering of the groin, as the semicircle and semi-ellipse will for those used in the elevations of the arches.

It now only remains to develop the surfaces of these arches, that is, to find the shape of the zinc or lead which would cover the roof of a railway station, or other building, when formed as here described.

The student is advised to work this study on a large scale on cardboard, and then to cut out the separate parts, which he can afterwards join at their edges, thus constructing an accurate model of the roof required.

Fig. 670.—Draw any straight line, and commencing at A, set off on it the distances into which the curve A C is divided (measuring on the *curve*, not on the springing line)—namely, the distances A, *a b c*, etc.

At the points on the straight line thus marked, draw perpendiculars; make the middle one equal to 6 *f;* those on *e e* equal to 5 *e;* those on *d d* equal to 4 *d;* those on *c c* equal to 3 *c;* those on *b b*, to 2 *b;* and those on *a a* equal to 1 *a*. Join the extremities of these perpendiculars, and the two curves meeting in a point, and joined by the original straight line, will form the development of the covering of the cylindroidal arch.

Fig. 671 is the development of the semi-cylindrical arch. As this is worked in precisely the same manner as the last, but taking the measurements from the semicircle, no further instructions are deemed necessary.

INDIAN RUBBER.—VI.

By George Gladstone, F.C.S.

MECHANICAL APPLICATIONS — MIXTURES — SPONGY CAOUTCHOUC — EBONITE, ITS CHARACTER AND USES — VULCANISED SOLUTIONS—AMERICAN TRADE.

In the last article some of the mechanical applications of vulcanised caoutchouc have been referred to, but the list is far from being exhausted.

Waterproof clothes, including articles made for fishing and yachting, and those who go long voyages at sea, form an important class of manufactures. Amongst these are swimming-belts and life-preservers filled with air, suits for divers, floats for life-boats, and even portable rafts and boats for military purposes or inland explorers. The principle upon which they are made has been described already.

To the surgeon the vulcanised caoutchouc is extremely useful. Not only is it available for making water-beds, elastic cushions, and the like, but the thread can be woven into belts and bandages, which shall be efficient and yet easy to wear at the same time. Besides this, some of their instruments are required to be sufficiently firm and also sufficiently pliable, and made of a material which shall not be affected either by the heat or the exudations of the body, a union of conditions which can be fulfilled by no other substance known.

There is yet one more very large class of applications for which it is specially adapted—the mechanical. Besides the carriage springs before mentioned there are railway buffers, engine packing, washers and pump-valves, wheel tires, hose pipes, and a great variety of other articles to which it is very largely applied. Vulcanised tubing, whether for the conveyance of gases or liquids, possesses great advantages over that made of any other material. For gas it can be used with movable burners for which no metal can be made available; while, on the other hand, a leather tube cannot be made sufficiently tight. For liquids leather piping is often used, but it is very liable to become leaky, and can only be preserved from becoming stiff and then cracking, by unintermitting use, or by being well lubricated when laid aside. This, however, is inconvenient, and often, from carelessness or otherwise, inefficient. The Indian-rubber article, on the contrary, may be left wet in the most careless manner without any damage to its efficiency. Water hose, or any other that has to bear considerable pressure from within, is made of sundry layers of the vulcanised rubber with canvas foundations, a single ply, as it is termed, being able to resist a pressure of about 20 pounds to the square inch; while one of four-ply, such as is used in fire-engines, will stand a pressure of about 175 pounds.

Rollers for letter-press printing may be made of it, the permanent elasticity and durability of the material recommending it for that purpose. To the calico-printer it is of greater advantage, being specially adapted for the manufacture of

printers' blankets, and also of furnishers. The blankets are formed of alternate layers of Indian rubber and cloth; by their use a printer can produce fine and delicate patterns, that could not result from the ordinary woollen blanket. These patent articles are capable of printing 25,000 pieces of cloth, and the power required is much diminished, in consequence of their peculiar elasticity requiring less pressure to produce the pattern. The furnishers are made with a roughened surface, which takes up the colour, and applies it to the engraved roller. The same furnisher can readily be applied to any colour without waste; the composition of the printing pastes and colours have no injurious effect upon them, which will perform their work satisfactorily for a series of years.

Its efficiency in deadening the force of concussions and in preventing jarring or vibration is so great that a long series of patents has been taken out for applying it to machinery in a variety of ways, and it has been very extensively adopted for bearing-springs and buffers on many of our railways. The test already given of its elasticity is sufficient evidence in this respect; but when a solid block is subjected to great pressure from above it tends to bulge out at the sides. An increased power of resistance can therefore be gained by confining the elastic block within metal rings, or by building up the spring or buffer of a number of thin laminæ instead of one piece, and separating the several laminæ by thin discs of metal. In this way the thickness and efficiency of the spring can be increased to any extent without more bulging than there will be in the case of one thin layer only.

Amongst these uses must be mentioned that of elastic tires for wheels; they are particularly convenient for trucking goods in warehouses or railway stations, as well as for bath and invalid chairs, as they deaden the sound at the same time that they prevent jarring, so that the truck or vehicle thus provided will roll along without the slightest noise, and in an extraordinarily soft and easy manner. A carriage or chair will, under such circumstances, last much longer than one which is only furnished with unyielding metal tires, as the fastenings have not the same tendency to work loose. The vulcanised tire is usually protected by having a narrow metal flange on each side, but of less depth than the thickness of the Indian-rubber band —in fact, only just sufficiently deep to keep the latter from slipping off the wheel.

Many of the mechanical applications involve the use of a large bulk of material, while at the same time they may not imperatively require the highest elasticity or other characteristic qualities that can be obtained. To meet such cases, various mixtures have been devised on economical grounds, and the following combinations have been found to answer well, though they are open to modification both in respect to the proportions of the ingredients and the temperature to be employed in vulcanising the compound. Eight parts of caoutchouc, with two of sulphur, and three of Stockholm pitch, or similar quantities of the first two articles combined with one of pitch, will make an article which after vulcanisation will be suitable for railway packing or other rough uses. It should be rolled out into sheets, or made into such other form as may be required, and then submitted for an hour to a temperature of 290° Fahr., pressure being applied during the process to prevent it from blistering or becoming porous. The common resin of commerce may also be used as a substitute for pitch, in which case eight parts of caoutchouc to one of sulphur and three of resin, or to two of sulphur and one of resin, will make suitable combinations.

For some purposes a spongy or cellular substance is found convenient. This character can be produced by mixing with a solution of caoutchouc, or a combination of caoutchouc and gutta-percha, a solution of chloride of sulphur; after a short time the whole becomes coagulated or gelatinised, and it should then be exposed to a temperature of about 212°, by immersing the vessel containing it in boiling water or otherwise, until the solvents are evaporated. Another plan of producing the same effect is to subdivide the Indian rubber into larger or smaller pieces, and to fill with them a vessel of any open or net-like construction of the required form, and then immerse it in the vulcanising solution: when the superfluous solvents have run off, after it is taken out of the bath, the several pieces will be sufficiently united to form an easily compressible and elastic mass suitable for cushion-pads and other purposes.

There are some other modes of making Indian-rubber tubing or hose pipe, which were not described in the previous article, but which ought not to be passed over altogether. It can be made of threads of a size proportioned to that of the hose, braided upon a core formed of rope which has previously been coated with treacle and glue, or glue and whiting, and made perfectly smooth; the braiding may be repeated, or a coating of Indian-rubber solution may be given, and when dry, rolled under pressure with a gentle heat. The hose is finished by immersing it in a vulcanising solution, which will produce the necessary change, and at the same time unite the several layers or coatings; lastly, the core is easily withdrawn by soaking it in boiling water. Another mode is to take worsted yarn of a suitable size, saturate and coat it with a solution of caoutchouc until the animal fibre is thoroughly covered; then braid in on a core as before, roll it under pressure with heat, either with or without a previous wash of Indian-rubber solution, and then immerse it in the vulcanising compound. A third plan of producing the same result is that of winding threads or narrow strips of Indian rubber spirally round the core, keeping the edges quite close, and, if necessary, winding another tape or thread over the first in the contrary direction; after this they should be rolled well under pressure, heated, and then subjected to the action of the vulcanising solution; the core is finally to be withdrawn as before described.

Some of the minor, but not the less important, mechanical applications may be advantageously illustrated by the annexed drawings of washers, which will show how they will make perfectly tight joints, which will not be affected either by the gases or liquids which may be passed through the pipes, or by the metal of which they are made. Fig. 1, in the next page, shows the simplest form of a flange-joint, with the Indian-rubber washer (marked 1*a*) which would be used in such case; Fig. 2, a socket-joint with its appropriate washer, marked 2*a*; and Fig. 3, a bevel-joint with the washer (3*a*) which would fit such an arrangement.

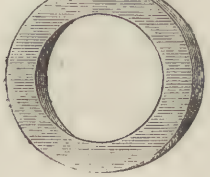
Ebonite or vulcanite are the special names given to that description of vulcanised rubber which is prepared at the highest temperature. It is black and hard like ebony, only very slightly elastic, and takes a good polish; is not affected by water, acids, whether hot or cold, alkalis or grease, or by any ordinary temperature. It can be used for almost all purposes in which horn is available; and more than that, because it can be had in much larger pieces and of any required form. Were it not for its cost it might be substituted for any hard wood, as a piece of ebonite can be wrought with ordinary cabinet-makers' and turners' tools like wood and ivory; or it can be moulded in the same way as the softer article is, the ebonite only requiring exposure to a higher degree of heat before being removed from the mould. Some of the most common things made of this description are combs, penholders, handles for knives, sticks, etc., watch-guards, brooches, bracelets, portable cups, taps, etc.; but there are many others for which it is particularly suitable, such as the splints used by surgeons in setting broken bones, and also for various kinds of apparatus where hardness combined with a slight degree of pliability and a resistance to the heat and secretions of the body of the patient are necessary conditions. The electrician and the experimental chemist also find it to be a very convenient substance of which to make some of their apparatus, on account of its being a non-conductor of electricity, as well as unaffected by most chemical substances.

In some of the processes of manufacture a good deal of waste in the shape of cuttings necessarily occurs, and at first some difficulty was experienced in converting them to a profitable use, as the vulcanised article cannot be wrought up in the masticator, and is less readily acted upon by solvents. They can, however, be dealt with in the following manner:—The scraps should first be passed through a mill to tear them into shreds, or under rollers to reduce them to thin sheets, so as to expose as great a surface as possible to the action of the solvent, and then boiled in oil of turpentine.

As a considerable temperature is necessary in this case, several of the ordinary solvents cannot be used with safety for this purpose, and turpentine is the only commercial article that can be conveniently employed. If the caoutchouc has not been strongly vulcanised, a temperature of 250° will be sufficient; but what has been originally converted at a greater heat will

require also a hotter solution, sometimes up to 312°, to dissolve it. Hard or horny caoutchouc, such as will come under the designation of ebonite, is, however, so intractable as not to be worth operating upon at all. The most convenient plan is not to keep up the boiling until the whole of the material is dissolved up, but to put in an excess of the latter, and when enough has been dissolved to make a solution of sufficient strength for the purpose intended, to pour that off, and then re-fill the vessel with fresh turpentine.

The vulcanised solutions are employed for coating cloths and other materials for rendering them air or water proof; for coating various articles to protect them from decay in consequence of wet; for the manufacture of cements and varnishes by mixing them with oils, pitch, resin, asphalte, etc., and generally for purposes where the high quality of the product is not of so much importance. When dry the solution possesses more or less the peculiar properties of the vulcanised rubber; but the process is of principal value, in an economical point of view, in using up what would otherwise be waste material.



1*a*.

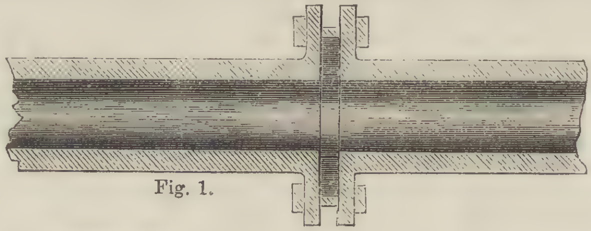
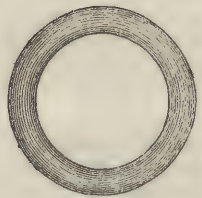


Fig. 1.



2*a*.

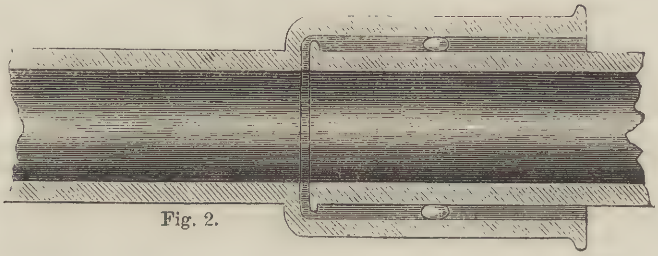
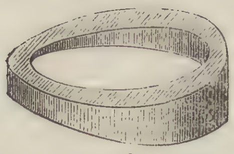


Fig. 2.



3*a*.

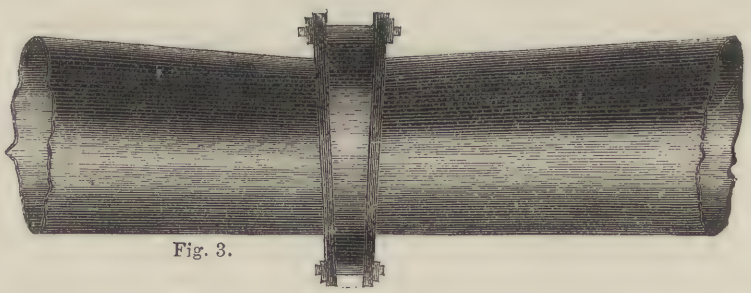


Fig. 3.

It has been already mentioned that the manufacturers of caoutchouc in the United States of America claimed the honour of having first discovered the process of vulcanisation. Goodyear's Indian-rubber works in that country were maintained on a large scale prior to that period, and it is indubitable that what led to the experiments which resulted in the employment of heated sulphur for this purpose, was the possession of some small scraps by Mr. Brockedon which had all the properties of the vulcanised article, and which had been furnished by a party from the other side of the Atlantic, who would not divulge the mode of its preparation.

The American manufacturers have, from the first, shown a great appreciation of the valuable properties of Indian rubber, and a most praiseworthy energy in applying it practically to every imaginable purpose. Those who had the privilege of visiting the Great International Exhibition of 1851 cannot fail to remember the very remarkable collection of objects of every description, manufactured from this article, in the space allotted to the United States, and which, indeed, formed the most notable feature amongst all the contributions from that country.

Those manufactories have generally been supplied with the raw material from Parà in Brazil, so that during the twenty years extending from 1836 to 1856, the United States imported from thence 3,886,534 pairs of native shoes, 15,951,491 lbs. of fine and mixed caoutchouc, 2,818,788 lbs. of coarse and inferior qualities; while the direct exports to England from the same port during those years only amounted to 117,135 pairs of native shoes, 7,784,262 lbs. of fine and mixed caoutchouc, 3,870,464 lbs. of coarse and inferior qualities; in addition to which, however, there were also shipped, *viâ* Cowes or Falmouth, and the European market, 22,640 pairs of native shoes, 32,824 lbs. of fine and mixed caoutchouc, some portion of which was doubtless ultimately landed in this country.

The East Indian caoutchouc, on the contrary, has been principally consumed by the English manufacturers; for while the exports from Singapore to Great Britain during the six years ending with 1855 were 1,547,616 lbs., only 524,832 lbs. were shipped to America.

The goloshes so largely used as overshoes in wet weather are principally manufactured in the United States, but most of the other Indian-rubber articles which are consumed in this country are made here.

There are some considerable works for the manufacture of Indian-rubber goods in Paris, which date back to the year 1828; but both the machinery required for the purpose and the men employed in the works had to be sent originally from London; and for some time after the works had been established in France the solution of caoutchouc used in waterproofing the French goods was supplied from this country.

GUTTA-PERCHA.—II.

By George Gladstone, F.C.S.

PURIFICATION — COMPOUNDS — MOULDING — TUBE-MAKING — STRENGTH OF PIPING—COATING OF TELEGRAPH WIRES—MANUFACTURE OF SHEET, BANDS AND CORDS—VULCANISING—SUBSTITUTES FOR GUTTA-PERCHA.

The first thing to be done in dealing with this article is to purify it from all the adulterations, accidental or otherwise, which may contaminate it. These are not a few, for a pound of the best gutta-percha as imported will often contain one ounce of impurities, and inferior qualities may not unlikely be found to include 25 per cent. of foreign matter: even sand and stones are not unfrequently incorporated with it by the unscrupulous collectors, much to the disadvantage of the buyer, not only because he may thus pay for much useless weight, but also on account of the damage which such substances cause to his machinery.

The usual plan of purifying it is as follows:—The lumps of gutta-percha are placed upon a sloping table, at the lower edge of which is a revolving disc, in which there are generally three slots radiating from the centre, which carry a similar number of knife-edges set in the same way as in a carpenter's plane. The disc is commonly driven by steam-power at a considerable speed, reducing the lumps of gutta-percha to thin shavings, which pass through and fall down in a heap on the other side of the disc. The slope upon which the feeding-table is made, forces the lowest lumps of gutta-percha down upon the disc so that they are caught by the knife-edges, and the process thus goes forward with rapidity, unless stones or other hard substances are met with, which seriously injure the blades.

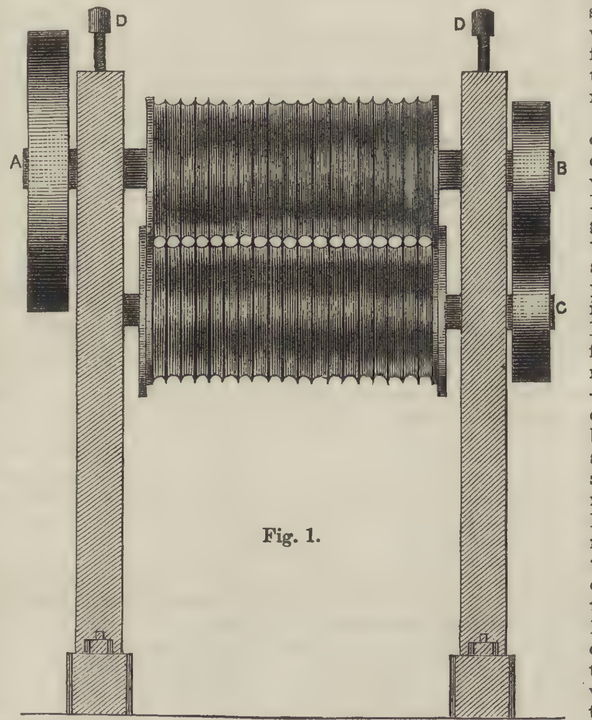


Fig. 1.

The shavings which are thus made are then conveyed to a tank full of boiling water; the waste steam from the engine employed for driving the slicing machine and other apparatus to be presently described, will suffice to keep the water up to the required temperature; and in these tanks the gutta-percha is stirred about until the impurities exposed by the cutting have been washed out of it. The gutta-percha being rather lighter than the water, floats on the surface, while the dirt sinks to the bottom. The warmth of the water has at the same time reduced the gutta-percha to a soft condition, and while in this state it is transferred to the teaser—a drum containing a rotating cylinder armed with teeth, similar in principle to the masticator of Indian rubber originally invented by Mr. Hancock —which tears it into shreds. The teaser is generally driven at the rate of about 800 revolutions per minute. From the teaser it falls into a tank below, where the rest of the impurities are separated, these settling to the bottom, whilst the gutta-percha, which is now sufficiently pure for most purposes, floats on the surface of the water.

To bring these shreds into a mass again, they are thrown into another bath of boiling water, which reduces them to a soft plastic state; and from this they are passed into the kneading machines (again similar in construction to those employed in the caoutchouc works), the projecting cogs in the cylinder of which press the still plastic gutta-percha against the sides of the drum until all the water and air-bubbles are expelled, and the contents are reduced to a thoroughly homogeneous mass.

An improved form of kneader is made by fixing two parallel rollers with screw surfaces so as to work nearly up to one another, and then passing the gutta-percha between them; in the threads of the screws diagonal notches are cut, by which the efficacy of their action is increased.

The experience gained already in the treatment of caoutchouc led the parties interested in that manufacture to secure by patent right, as rapidly as possible, the application of gutta-percha to almost all the purposes for which the former article was adopted, and with only just such modifications in the processes as the different nature of the article dictated. It will be unnecessary to go through these in detail, as they have been already described under the head of "Indian rubber." It will suffice to say that it is likewise treated with sulphur or sulphurous compounds, which, according to the temperature employed, will render it more tenacious and pliant, or on the other hand much harder, and always less susceptible to the influence of heat. It is compounded with ochre, silicate of magnesia, lime, asphalte, pitch, and all kinds of conceivable substances, either for the purpose of producing a softer surface, or to impart to it certain colours, or to make a varnish, or—which must undoubtedly be the sole object of many of the patents which have been taken out—to furnish a cheap substitute for the pure article without any regard to quality.

There are, however, certain operations which can be conducted upon principles which would not answer in the case of Indian rubber, and for which gutta-percha is in all respects the more suitable material. The simplest of these applications is perhaps that of forming mouldings or other impressed figures. By reducing it to a plastic state, for which purpose it is only necessary to warm it thoroughly —which can be most conveniently done by immersing it in boiling water—it can be easily stamped out with a die into a scroll or beading or other simple form, or can be moulded by hand into a much more elaborate device. For these purposes the material will remain sufficiently plastic so long as it retains a temperature of 130° to 140°, and such ornamentations can be bent or otherwise adapted to, and also nailed to the framework for which they are intended, without fear of breaking, or even of any change in form after having cooled down to 110°.

Articles of more complicated form can, however, be produced by forcing it into moulds, such as would be used in metal-work. For this purpose the moulds must be made of metal in segments, and the several pieces firmly bolted together; there must be a good-sized aperture at one end for the admission of the gutta-percha, and smaller ones for the escape of the air wherever the particular form of the object to be made may render such necessary. The large aperture is fitted to the nozzle of a cylinder which is filled with the plastic gutta, and then the piston worked by a screw or other power forces the contents through the nozzle into the mould. As soon as threads of the gutta are seen to issue from each of the small air-holes, further pressure is discontinued, the mould unscrewed, and the object cut off and trimmed. In order to prevent the material from becoming chilled, which would render it too refractory, the apparatus should be inclosed in a steam-jacket, the temperature of which can be regulated with precision, and maintained at such a point as will make the gutta unite in the mould into a uniform solid mass.

Very similar to this in principle is the manufacture of gutta-percha tubing, which is carried on upon a very extensive scale, as this is one of its most valuable applications. The purified

material is transferred from the kneaders into the cylinder, which communicates with a mould formed of an iron tube open at the further extremity, and containing in the centre a solid circular core; tubes and cores of various sizes are kept so that they can be changed when required according to the size of piping to be made. Pressure being applied by means of a piston, as in the former case, the gutta-percha in the cylinder is forced through the tubular die, and issues from the open end in the form of a hollow pipe without any seam or joining of any kind; but at the temperature required to keep the material soft the piping cannot be handled without destroying its circular form, and it would even collapse if left to itself; it is therefore made to dip under cold water as it comes forth from the mould, and this both expedites the cooling and keeps the tube distended until it is sufficiently firm to retain its proper shape. The water-trough should be about 50 feet long, and by the time it has traversed that length it will be in a fit condition to be wound off upon a drum. By a special arrangement for keeping the cylinder constantly supplied with material, the piping can be made of any length without joining, a thing which cannot be done with any other known material.

Thin pipes thus made are largely used for speaking-tubes in houses and public offices, on account of their high acoustic properties; and piping of all sizes is extensively employed in many manufactories for conveying water and other liquids, especially as it is altogether unaffected by acids, saline solutions, and fermented liquors, so that it is equally available in breweries, chemical works, and all others in which large quantities of liquids have frequently to be transferred from one receiver to another. In water-works more particularly its power of resisting internal pressure is an important consideration. Experiments have therefore been made to ascertain this point; and at the Birmingham water-works it was found that tubes of the diameter of $\frac{3}{4}$-inch and $\frac{1}{2}$-inch respectively, after being attached to the main and subjected for two months to a pressure of 200 feet head of water, had not deteriorated in the slightest degree. Having determined this point, the next thing was to test their strength, and with this object they were connected with the hydraulic proving pump, the usual load of which is 250 pounds to the square inch. As the gutta-percha pipes showed no signs of strain at this pressure, it was then worked up to 337 pounds without affecting the pipes. The pump was then loaded to the greatest pressure the valve would sustain, and the gutta-percha still remained perfect; it had slightly expanded during the trial, but on the force being withdrawn it contracted to its original dimensions—a beautiful test of its thorough elasticity, though requiring such a force to show it as to render it practically devoid of that quality so far as all ordinary purposes are concerned.

The making of tubes naturally lead us to what would appear to be a very different application of gutta-percha, the coating of telegraphic cables. The qualities of this substance as an insulator of electricity have already been mentioned. These combined with its resistance to the action of salt water, and the ease of manipulation, have resulted in its very general adoption for the coating of the copper wires used in submarine telegraphic communication. We have now only to deal with the last point. In "The Electric Telegraph" (Vol. I., page 181) is a diagram drawn of the actual size (Fig. 11), representing a cross-section of the Atlantic telegraph cables which were completed in 1866. Of these the first broke in mid-Atlantic in the course of laying down in 1865, and was recovered next year, when both it and the new cable were successfully laid. Both cables have remained efficient ever since. It will be seen that the part shaded dark, which immediately surrounds the seven central wires, consists of four rings: these represent so many layers of gutta-percha, each separated by a thin film of varnish known as Chatterton's compound. It is with the four rings of gutta-percha that we have now chiefly to do. They are made upon the same plan as the hollow tubing, except that the core of the mould, instead of being a fixed piece of metal, consisted of the actual copper wire to be coated, and which was drawn forward through the mould at a rate proportional to that at which the gutta-percha was forced in by the piston. The first layer having thus been deposited, a thin coating of Chatterton's compound, of which gutta-percha is the principal ingredient, is spread over it; and when dry this is ready to enter a second mould of about one-tenth of an inch greater internal diameter than the preceding, in passing through which it acquires a second layer, and so on until four perfect coatings of the insulator are deposited around the central wire, each separated by a film of varnish. The exterior portions of the cable shown in the diagram are merely added for the sake of strength, and to protect the insulating material from internal injury. In preparing the gutta-percha for this purpose unusual precautions are taken to ensure its purity; the crude article is rasped down very fine before being washed, and after being worked in both hot and cold water, it is placed in cylinders having bottoms of fine wire gauze, through which it is forced by a hydraulic machine at the temperature of 212° Fahrenheit, preparatory to its being sent to the kneaders. Some of the earlier submarine cables, insulated with gutta-percha, have been taken up, and on examining them no sensible deterioration in the quality of the article has been perceptible in those parts which have been completely and continuously submerged. The Irish cable from Holyhead was thus examined after seven years' use, and that which stretched from Orford Ness to Scheveningen after five years' submergence, with the result stated.

The manufacture of sheet, bands, and cord is more simple that what has been already described; but these form a very important part of the work at any factory, as there is a great demand for gutta-percha in these forms. The rolling machine, in which the first of these is produced, consists of a pair of steel cylinders fixed horizontally one above the other in a frame furnished with adjusting screws, by which the space between the cylinders can be varied according to the thickness of sheet required. The principle is illustrated by Fig. 1 in the preceding page, only that in making sheet the surfaces of the cylinders are smooth. They revolve at an equal speed in opposite directions, the one being driven by an endless band from the engine which is connected with the wheel A, whilst the motion given to the first is at the same time communicated to the second by the cog-wheels B and C which work into one another. At some little distance is a drum which is driven by the same power, and carries an endless web which passes over the cylinders. In front of the latter is a table upon which the plastic material is put, just as it leaves the kneaders, and from which the machine is fed by the attendants. The gutta-percha is carried between the cylinders as they revolve, and these roll the lumps out into a sheet, which cools and hardens as it passes to the drum in the distance. When a very thick sheet is being rolled out, the cooling is expedited by causing an artificial current of air to play upon its surface as it passes from the cylinders to the drum.

If the gutta-percha is to be converted into narrow bands, a series of knives turned up on edge are so arranged as to cut it through at the widths required, just as it passes out from the rollers.

The diagram which has already been referred to illustrates an arrangement devised by Mr. Hancock, either for cutting very thin films of gutta-percha into narrow slips, or of making solid round cord. The surface of the two cylinders shown is cut into semi-circular grooves, and so arranged that when brought together by the adjusting screws D, D, the grooves shall exactly correspond and form true circles. A thin film passed between these as they revolve will be cut into narrow slips, but a sheet at least as thick as the extreme diameter of the spaces will, by the same apparatus, be converted into round cord. The substitution of one flat surface will evidently produce a semi-circular cord, and by varying one or both of them any simple form can be given to the gutta-percha at pleasure. The thin films are cut when cold, but in making cord the material must be warmed sufficiently to render it plastic, say to about 200° Fahrenheit.

The mode of vulcanising gutta-percha is similar to that adopted with Indian rubber, but the effect of the process is less marked. If 2 per cent. of chloride of sulphur be used, the resulting article will be capable of extension when heated to 100° or 120°, and if allowed to cool when thus stretched it will continue extended until re-heated, when it will resume its original dimensions. An increase in the quantity of sulphur combined with it is attended by greater resistance to the influence of heat: 10 per cent. of chloride of sulphur renders it unaffected by boiling water, and 15 per cent. produces a hard and horny substance.

The value of gutta-percha being considerable—the best com-

mercial article being usually worth 3s. per pound wholesale—any other substance which will really serve as a substitute is worth attention. The juice of the Balatta tree is capable of replacing the lower qualities, and it can be procured in considerable quantities from British Guiana. The tree abounds there in the forests, and it will allow of being tapped every two months. Another tree which yields a similar article grows abundantly along the whole line of the Western Ghauts in Travancore, at an elevation of 2,500 to 3,000 feet above the sea-level.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLIV.—DR. JAMES BRADLEY, F.R.S.

ONE of England's most celebrated astronomers, James Bradley, was born at Sherborne, a village in Gloucestershire, situated six miles north-west of Burford, and five miles eastward of North Leach, in the year 1692—the stirring epoch of La Hogue, of Steenkirk, and the massacre of Glencoe.

In due time he went to Oxford, and was admitted a commoner of Baliol College on the 15th of March, 1710, and took the degree of Bachelor on the 14th of October, 1714, and that of Master of Arts on the 21st of January, 1716. As his friends destined him for the Church of England, his studies were regulated and arranged with that view; and as soon as he was of the proper age to receive holy orders, the Bishop of Hereford, Benjamin Hoadley (who had been translated from Bangor, and was afterwards Bishop of Salisbury), who had conceived a great esteem for him, gave him the living of Bridestowe, near Oakhampton, in Devonshire; but soon after he was inducted to that of Llandewy Welfrey, in the county of Pembroke.

Though he continued to fulfil the duties of his sacred profession, he also devoted some time to astronomy, and made such observations as led to those discoveries which distinguished him as one of the greatest astronomers of the Georgian era—observations which won him the notice and the friendship of Sir Isaac Newton, Dr. Halley, and many other members of the Royal Society of London, into which he was soon elected as a member. Among his friends and patrons was the then Lord Chancellor, Thomas Parker, who was created Viscount and Earl of Macclesfield in 1721.

Soon after, the chair of Savilian professor of astronomy at Oxford became vacant by the death of the celebrated John Keil, and on the 31st of October, 1721, James Bradley, then in his twenty-ninth year, was appointed to succeed him. On receiving this more congenial appointment, Mr. Bradley resigned his church livings, and applied himself wholly to the study of his favourite science.

He discovered, in course of his observations, which were almost innumerable, the settled laws of the alterations of the fixed stars, from the progressive motion of light, combined with the earth's annual motion about the sun, and the nutation of the earth's axis, arising from the unequal attraction of the sun and moon on the different parts of the earth.

Of these effects, the former is called the *aberration* of the fixed stars, the theory of which he published in 1727, and the latter the *nutation* of the earth's axis, the theory of which he produced ten years subsequently, so that in this space of time he communicated to the world two of the grandest discoveries in modern astronomy, and these must for ever make a memorable epoch in the history of that science.

As lecturer in astronomy and experimental philosophy at Oxford, he succeeded Mr. Whiteside in 1730. This office proved one of considerable emolument to him, and he held it till within a year or two of his death, when ill health compelled him to resign it. The esteem and friendship of his colleague Halley he always preserved, and the latter being quite worn out by age and its consequent infirmities, thought that he could do no better service for the science of astronomy than to procure for James Bradley the office of Regius Professor of Astronomy at Greenwich, an appointment which he had himself held for many years with honour and reputation. With this kind view, he wrote many letters, requesting his friend's permission to apply for a grant of the reversion of it, and even offered to resign in his favour; but ere this could be adjusted, Dr. Halley died, and Dr. Bradley obtained the place in February, 1741, through the interest of another friend—the Earl of Macclesfield—who was afterwards President of the Royal Society; and it was upon receiving this appointment that the University of Oxford conferred upon him the diploma of Doctor of Divinity.

On a rising ground in the park of Greenwich, commanding one of the richest and most varied prospects that can well be conceived, stands the Royal Observatory, which must for ever be associated with the names most celebrated in astronomy. It contains excellent apartments for the Astronomer Royal, and the finest instruments that art can provide. It was founded by Charles II. in 1675, and in the following year Flamstead began that famous series of observations which has been continued by his successors to the present day.

"Among the astronomers which the Royal Society has produced," says La Place, "I shall cite Flamstead, one of the greatest observers that has ever appeared; Halley, rendered illustrious by his travels, undertaken for the advantage of science; by his beautiful investigation concerning comets, which enabled him to discover the nature of the comet of 1759; and by the ingenious idea of employing the transit of Venus over the sun to determine its parallax. I shall mention *lastly Bradley*, the model for observers, and who will be for ever celebrated for two of the most beautiful discoveries ever made in astronomy—the aberration of the fixed stars and the nutation of the axis of the earth."

To Bradley succeeded Nathaniel Bliss, M.A., in 1762.

As Astronomer Royal the former was in his proper element, and with unwearying diligence pursued his observations; but however numerous the collection of astronomical instruments at Greenwich, it was impossible for an observer such as Dr. Bradley not to desire to increase them, as well to answer his own particular views as in general to make observations with greater exactness.

He took the opportunity, therefore, in 1748, during a visit of the Royal Society, made annually to examine the instruments and receive his observations for the year, to urge so strongly the necessity of repairing the old instruments and providing new, that an application was made to George II., who was pleased to order £1,000 for the purpose. Bradley was overjoyed on receiving this sum, which he disbursed, with the assistance of the eminent Mr. Graham and Mr. Bird, and thus succeeded in furnishing Greenwich Observatory with as complete a collection of astronomical instruments as the most skilful enthusiast could desire.

The living of the church at Greenwich having become vacant during Dr. Bradley's residence at the Observatory, it was offered to him; and upon his declining to accept it, from the conscientious scruple "that the duty of a pastor was incompatible with his other duties and necessary engagements," George II. granted him a pension of £250 over and above the astronomer's original salary from the Board of Ordnance, "in consideration," as the Royal warrant of 1752 expresses it, "of his great skill and knowledge in the several branches of astronomy and other parts of mathematics which have proved so useful to the trade and navigation of this kingdom."

In 1748 he became entitled to the benefaction of £30 yearly willed to the lecture-reader and experimental philosopher at Oxford by Nathaniel Crewe, originally Dean of Chichester, and Bishop of Oxford in 1671; and honours came upon him from other quarters. Thus in 1747 he was elected a member of the Academy of Sciences at Berlin; in 1748 of that of Paris; in 1754 of that of St. Petersburg; and in 1757 of that of Bologna.

Dr. Bradley was remarkable for his placid, gentle, and modest character. Though he was a fluent speaker, and possessed the happy art of expressing his ideas with clearness and precision, yet no man was a greater lover of silence, for he seldom spoke, save when he deemed it absolutely necessary to do so. Nor was he more inclined to write than to speak, for he published very little, and he had a strange diffidence which made him afraid that his works might fail to please, and hence injure the reputation he had already won. Yet many of his papers were printed in the *Philosophical Transactions of the Royal Society*. His private character was in every respect estimable, and his modesty prevented him from soliciting that attention and patronage which were necessary to ensure the publication and success of great and even small works in those days, and which

reduced authorship to a system of degrading adulation and toadyism.

As a man of science and observation, the public character of Dr. Bradley is fully established by his works. His observations made at the Royal Observatory, Greenwich, during a period of twenty years, were collected in thirteen large volumes, and in the year 1776 were transferred to the University of Oxford, on condition that they should be printed and published by that learned body.

By too close application to study, Dr. Bradley, for nearly two years before his death, became afflicted by serious depression of spirits, and this interrupted the course of his useful labours. This distress, the result of over brain-work, took the form of apprehension that he should outlive his rational faculties; but the terrible evil that he so much dreaded never came upon him. In June, 1762, he was seized with inflammation in the kidneys, and this ailment terminated his existence on the 13th of the following July.

His death happened at Chalfont, in Gloucestershire, when he had attained his seventieth year; and he was interred at Minching Hampton, in the same county.

In June, 1791, the Board of Longitude, seeing no prospect of the publication of those MSS. committed twenty-five years before to the care of the University of Oxford, passed some resolutions respecting the right of the public to possess these "observations," which being therefore transmitted to the Vice-Chancellor, the Board was, in consequence, informed that the delegates of the press in the University were at last proceeding with the work. In 1798 the first volume was published in a very splendid form, under the title of "Astronomical Observations at Greenwich from the year 1750 to the year 1762."

In 1818 there also appeared in folio, edited by F. W. Bessel, "Fundamenta Astronomiæ pro anno 1755, deducta ex observationibus viri incomparabilis James Bradley."

OPTICAL INSTRUMENTS.—XXIV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN (*continued*).

THE late Andrew Ross was the first to describe a practical arrangement of a triple condenser, which he made in 1836 for Dr. Leeson, at that time Lecturer on Chemistry at St. Thomas's Hospital, from whom he received a *carte-blanche* to construct the most perfect demonstrating lantern his optical knowledge would dictate and his skill accomplish. This condenser is represented at R (Fig. 116): it consists of two plano-convex lenses, and one double-convex lens. The principle of introducing a third lens, for the purpose of dividing the total refraction, in

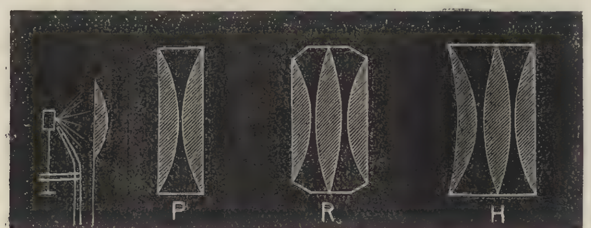


Fig. 116.

a combination of short focus, is correct in practice, as may readily be found by experiment, and is of special value in improving the performance of old-fashioned instruments. Thus P (Fig. 116) shows how the large condensers in the lanterns at the Polytechnic Institution have been made to give more light, by the introduction of a small plano-convex lens between the lime-ball and back lens of the pair of large plano-convex lenses, which necessitate the light being brought in closer to the condensers, a hint probably gained from the arrangement of Mr. Warner, the optician, who effected several improvements in lantern construction, which, however, failed to meet with due appreciation. In the Christmas season of 1864-5 I introduced the form of triple condenser shown at H (Fig. 116), which gives a bright flat disc on the screen, but this is a costly method of attaining the desired end, and I afterwards found I could accomplish it by using short-focussed plano-convex lenses, arranged as at E (Fig. 113, page 257), made of a very bright white flint glass (refractive index about 1·6, crown-glass being 1·5), to compensate for the extra thickness of the lenses employed—one of many optical methods of "robbing Peter to pay Paul," not unfrequently followed in practical optics. I still think the triple arrangement advantageous in its application to weak lights, such as the Argand burner, where every additional increment of light is of the greatest value to the exhibitor, a point not felt to the same extent when we are dealing with intense illuminators.

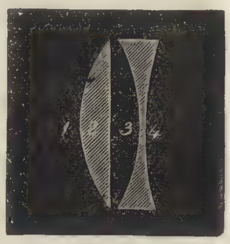


Fig. 117.

In 1861 I had occasion to communicate with Sir John Herschel on the combination F (Fig. 113), referred to by Sir David Brewster in his work on optics, in connection with spectroscopic investigations, which led to the revision of the original formulæ. This was conveyed to me in a letter which, with Sir John's permission, I (as one of the editors at that date) published *in extenso*, with diagrams, in the *British Journal of Photography*. The following extract is of importance in connection with the subject of condensers:—"I regret to say that I fear I have unintentionally misled Sir David Brewster in reference to the radii of the surfaces of a double crown lens corrected for spherical aberration. Your note having recalled the subject to my notice, I have been again looking over the subject, and I have detected an error in one of the *numerical* coefficients of the formula I worked on (see *Phil. Trans.*, 1821), where in section 10 of my paper on object-glasses the value of β instead of $+\frac{32}{27}$ there set down should be $+\frac{14}{27}$, which vitiates the subsequent conclusions so far as a combination of two lenses of *crown glass* is concerned, and renders the radii above given inapplicable. *In point of fact, the spherical aberration of a convex lens requires for its exact correction a lens of a concave character, of inferior power*; and I only wonder that the lens I had constructed for a burning glass on those radii worked so well as it actually does. Had it been otherwise, I should have been led by its bad performance to re-examine carefully all the steps of the calculation, and the error must have been detected. I have still the lens by me, and it gives a clean and perfectly defined focal image of the sun, with a remarkable freedom from loose light when thrown upon a white screen."

"The following combinations, in which the spherical aberration for glass of refractive density 1·500 is corrected, are computed with the *correct* value of β. They all suppose a compound focal length = 2, and a convex resulting character of the combination."

Fig. 117 is a single example out of the six combinations Sir John Herschel gave as types of his corrected formulæ:—

	Surface.	*Curvature.*	*Radius.*	*Focal Length.*
PLANO-CONVEX ...	1	2·0000	0·5000	+ 1·0000
	2	0·0000	∞	
DOUBLE CONCAVE	3	— 0·7932	— 1·2607	— 0·5000
	4	+ 0·2068	+ 4·8356	

Mr. Robert H. Bow, C.E., of Edinburgh, who has paid considerable attention to the important question of the best form of condenser for lantern purposes, in commenting on the above paper in the same periodical, says: "In the six aplanatic combinations given by Sir John Herschel, the convex lens is assumed to be either equi-convex or plano-convex, and of double the power of the concave lens, and both lenses are of the same material. But, of course, other forms of the convex lens could be adopted, and other proportions between the powers of the lenses introduced in carrying out the application of the peculiar leading principle employed in bringing about the correction of the spherical aberration, which is the transmission of the rays through the concave lens in a less symmetrical manner than through the convex one. But when a powerful combination with a large aperture is required to be nearly freed from aberration, as in the condensers of lanterns and solar microscopes, *the introduction of a concave lens is very objectionable, as reducing the grasp and increasing the cost.*"

Mr. Bow considers that the original formula of Sir John

Herschel is preferable. "The leading principle in this other method of correction consists in sending the marginal rays, which suffer over-refraction at a first convex lens, through a second convex lens so formed that these rays will pass disproportionately near to its axis. At the second lens, therefore, the marginal rays will undergo a reduced deviation compared with what attends the more central rays. Fig. 113, G, shows such a combination, which was found to give a focus remarkably free from scattered light when tested as a burning glass, with the parallel rays from the sun entering at the convex face. The first or larger lens is a crossed one, having a focal length $f=10$, while the second lens is a meniscus, with $f = 17{\cdot}83$.* We shall endeavour to explain more particularly the principle of the correction by means of the exaggerated diagram (Fig. 118).

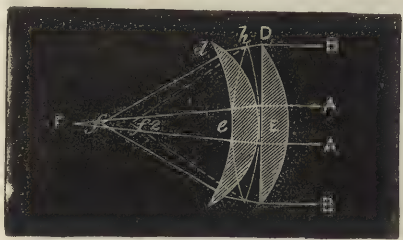


Fig. 118.

"Let $d\ e$ be the meniscus used, and let the dotted lines $h\ e$ represent an equivalent bi-convex second lens. Now, the different effects of the two lenses d and h are at once apparent. For each of these the passage of the nearly central ray A E e may be considered the same, and therefore the geometrical focus F as common to both arrangements; but for the marginal ray B D the effects are very different. In the case of the meniscus the place of passage d lies so low that the equivalent refracting angle is reduced, compared with the angle of the dotted lens at h. The deviation at h would therefore be on this account greater than at d, and the difference is still farther increased by the passage of the ray through the double convex at h being more oblique than the passage of the same ray through the meniscus at d. Then, apart from the refraction at h being greater than at d, it will be seen that the fact of d being farther removed than h from D has a reducing effect upon the aberration F f.

"The principles involved in the correction for spherical aberration may therefore be stated as follow:—

"(1.) The distribution of the total refraction between several lenses.

"(2.) The passage of the rays symmetrically, or approximately so.

"(3.) The bending away of the lenses from one another towards the margins.

"These principles are bound up very much the one in the other, but the combination shown by Fig. 119, also due to Sir John Herschel, exhibits in a very marked manner the importance of the third principle; for in this combination the first lens is placed in the worst possible position with respect to the second principle, which is therefore sacrificed in order to bring the third into powerful play, *the final result being good.*"†

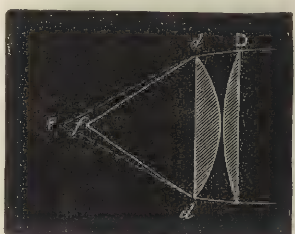


Fig. 119.

"With a large cone of light we cannot get a perfectly aplanatic lens; for, if the extreme and central rays be made to cross the axis at the same point, some of the intermediate rays will be thrown out. We must, therefore, be content with some amount of aberration, and it is best that this should be positive; that is, that there should be a slight excess of refraction of the marginal rays. There is, indeed, a certain advantage attending a moderate amount of aberration, since, were the condenser absolutely free from such, the centre of the disc of light would be more highly illuminated than the margins, but a moderate action of the aberration will have a tendency to equalise the distribution."

Mr. Bow gives the following combinations as examples of efficient condensers, which afford useful data:—

(1.) *Herschel's Original* (Fig. 113, G) radii = (counting from the source of light) − 6·29, 3·69, 35, and 5·83; focal length = 6·41. This he regards as the most perfect, but on account of its concave surface, the most costly in proportion to its power.

(2.) *Herschel's Double Plano-convex* (Fig. 119), radii = ∞, 4·35, 10, and ∞, which gives an even disc of light on the screen, and is inexpensive to make.

(3.) *Crossed Lens corrected with a Convexo-plane Lens*, radii = ∞, 6, 42, and 7. This works well with cheap forms of lenses.

(4.) *Double Convex corrected with a Convexo-plane*, radii = ∞, 7½, 10, and 10.

(5.) *Single Crossed Lens*, radii = 21 and 3½.

TABLE OF COMBINATIONS.

No. of lens combination	1	2	3	4	5
Diameter of first lens	5·16	5·52	5·56	5·34	6
Diameter of second lens	6	6	6	6	0
Combined thickness	1·47	1·45	1·49	1·43	1·93
f for first lens	17·83	8·7	12·0	15	6
f for second lens	10·00	20·0	12·0	10	0
f for combination	6·41	6·06	6·0	6	6
Longitudinal aberration	0·44	0·76	0·63	1·33	2·26
Lateral aberration	0·25	0·45	0·36	0·85	2·27
Angle of cone d F d'	55°	54°	53½°	51°	60°
Angle of cone $d\ f\ d'$	59½	61½	60	64½	92°
Deviation of extreme ray = F $d\ f$..	2¼°	3¾°	3¼°	6¾°	16°

Mr. Bow considers that such combinations are only to be employed for bringing divergent rays parallel, and that to complete the condensation according to this view, a third lens should be placed in front, as at Fig. 116, to suit the distance of the other focus; but if that focus is a long one, a double combination could, by altering the position of the source of light, be made to converge the rays with but slight change in the aberration calculated. This opinion brings us to consider a condenser constructed for Professor Henry Morton, of the United States, on a different plan to any hitherto described. In this arrangement he employs three lenses as *a collector*, with a small lime-ball placed at *the exact point* of the principal focus, for the purpose of bringing the divergent rays from the source of light into a parallel beam, and gaining the largest angle of incident light attainable, and then converging the parallel rays towards the axis (when required) by means of a double-convex lens, which he regards as "the condenser" proper. In all the arrangements previously described the source of light has to be withdrawn from the exact point of the principal focus of any combination to render the rays convergent, and produce a conjugate focus, thus reducing the value of the angle of the rays incident on the condenser, according to the principle illustrated by Fig. 114, page 258. The form of his "condensing lens" is varied with the nature of the accessory apparatus to be employed, and can be changed without disturbing the light or apparatus. This is arranged to be movable within certain limits, but not so as to allow the rays to come to a focus on a microscopic object, Nichol prism, objective, etc., and cause injury or destruction to valuable appliances by the concentrated heat of the source of light. The collectors embrace an angle of light of 80°, the diameter of the back lens being 4¼ inches and 2¾ inches focus. This is a plano-convex, with a radius of curvature of 4½ inches. The two other lenses are 5 inches diameter. The middle lens is a meniscus with radii of curvature (counting from the light) of 30 inches and 6 inches. The radii of curvature of the third lens are 52 inches and 8¾ inches for the back and front faces respectively. The condenser is a double convex of 15 inches focal length. As by moving the source of light we have a simple and ready means of producing

* Gravett's condenser was of this type (Fig. 113, G), and his curves were, for glass of refractive index 1·5 = 6·56 in., 2·39 in. − 26·25, 4·38; focal length of each lens = 7·5; combined focus = 3·75. For glass of refractive index 1·6 = 5·25 in., 2·33 − 63·0 in., 4·50; focal length of each lens = 7·0 combined focus = 3·5. The diameter of the back lens = 4·1 in., that of the front lens = 5 in.

† Mr. Sutton, the late editor of *Photographic Notes*, an accomplished mathematician and optician, says—"The symmetry of two equal plano-convex lenses having their convex sides in contact, is such as to give theoretically the most perfect sharpness of the image; the source of light and the enlarging lens being placed at equal distance from such a condenser."

parallel, converging, or diverging rays at will, I question whether, when using a powerful illuminator, such an arrangement as Professor Morton describes is of real advantage to the physical demonstrator, though the application of the principle to weak lights is quite worth consideration, to gain the greatest attainable angle of rays any "collector" will subtend, and then converge the parallel beam (for showing pictures) by a "condenser" of such form as will correct the spherical aberration.

Mr. Grubb has constructed an achromatic condenser for a gas microscope, the collector of which "receives and transmits an angle of light of 90°;" but no authentic description of this has, I believe, as yet been published.

A concave surface next the light is preferable to a plane one, as there is little or no reflection from the former, so all or the bulk of the incident rays pass through the condenser. As a rule, it should be observed that if the distance between the light and the condenser be less than the distance between the power and the condenser, the flattest side of the combination that forms the condenser should be turned towards the source of light, or that side which depicts on paper held in its focus the sharpest image of a distant object. When, however, the source of light is of considerable size, as in the case of an Argand flame, this rule is of less consequence than when we are dealing with a point of light of great intensity. The quality of the glass of which a condenser is made is of less consequence when the source of light is of some size, for then wavy lines, spiral striæ, specks, air-bubbles, and even irregularities in the curvature of the lenses, are scarcely appreciable; but if the lime-light or electric light is to be employed, the greatest care must be taken in the selection of the glass, and the surfaces must be guarded from injury, for any contained air-bubbles, spots, or deep scratches, especially if in the lens next the stage, would put in an appearance on the screen in a manner not to be desired. Wavy lines and striæ, though objectionable, are comparatively of minor consideration, as such defects do not make themselves so palpably felt during an exhibition. It may here be noted that while striæ and wavy lines in the object-glass or power must be regarded as grave defects, air-bubbles, spots or scratches are (unless numerous) of comparatively small importance, as they merely cause an inappreciable diminution of the light. In some instances the surfaces of the condenser lenses present a greyish tint, arising from imperfect polishing. This is a grave defect, and an unpardonable one, as it results from the negligence of the workman, and stands on a footing with defective curvature, both of which defects can only be attributable to defective supervision on the part of the optician. It is usual to find the ordinary run of double condensers made out of crown and flint glass, which has led to the erroneous supposition that such combinations are "achromatic condensers." As the aim of condenser construction is to pick up the greatest amount of light practically attainable, I think it is better to dispense with green-tinted crown glass, and make both lenses of the most pellucid white flint glass attainable, which, from its greater refractive power, also allows of the lenses being thinner.

As most opticians occasionally meet with over-fastidious customers, I think it right to state that one must not expect to find such perfection in a magic-lantern condenser as characterises an achromatic photographic lens or microscopic object-glass; and as long as any slight defect does not interfere with the proper performance of the combination, it would be unreasonable to expect that which could only be attainable at a considerable increase of cost, without any adequate practical advantage.

A condenser may be considered to perform well when it is of as short a focus as $2\frac{1}{2}$ inches, or even less, and *when properly centered and focussed with the light*, will distribute the collected rays over the disc on the screen, without one part being more brightly illumined than another. If the margin of the disc is brighter than the other parts of the field, then the curves of the lenses are too great in relation to their diameter. A large condenser is not of necessity a good one, since a $3\frac{1}{2}$ or 4-inch combination will show a better enlargement of a hemi-stereograph than one of 6 inches diameter.

The ordinary run of the better class of condensers is $3\frac{1}{2}$ inches in diameter, but I consider *the standard size* should be 4 inches in diameter, as the half of a transparent stereograph, now so often used as a magic-lantern slide, measures $3\frac{1}{4}$ across the diagonal, and the diameter of a condenser should always be half an inch more than the greatest diameter of any slide used.

As all condenser lenses are thick, it is very necessary before commencing an entertainment to warm them through gradually, especially the one next to the light, or the exhibitor may be placed *hors de combat* by the cracking of the lens, as soon as the lime-ball gets thoroughly incandescent, especially if the weather be cold, and for a certainty if a draught of cold air should strike upon the back lens at the moment of opening the door of the lantern; so that an eye ought to be kept upon the direction of open doors and windows, and the lantern be duly shielded. The lenses may be best warmed by placing them in a tray on wash-leather, or a cloth, before a fire, or in an oven, otherwise they must be gradually warmed by slowly raising the heat of the lime-cylinder, and bringing it nearer and nearer to the lens. This also dissipates moisture, which would otherwise dim the lenses for a time. After an exhibition, care should be taken that the lenses are not too suddenly cooled. The lenses should not fit tight into the brass mounting tube, or they would crack on expanding with the heat.

The Concave Condenser.—When the lantern is required for the gas microscope, and it is desirable that the rays from a lime-ball or the electric should be brought to an exact conjugate focal point, I believe it would be better to employ a very perfectly made concave reflector of silver deposited on glass, as shown in Fig. 120, in which case, if a lime-ball is used as the source of light, it should be made as small as possible. Andrew Ross employed this method, and Chadburn has found it the best arrangement for his opaque microscope.

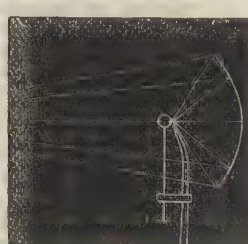


Fig. 120.

The celebrated Euler proposed to substitute for the lens of the lantern a concave mirror, perforated in the middle like that of a Gregorian telescope: this was to be placed in the interior of the lantern with its polished surface towards the light and its convexity towards the object. The light was to be so disposed that none of it should pass directly through the aperture in front of the lantern so as to fall on the screen; and that which was reflected from the concave mirror, after falling upon one with a plane surface, was from thence to be reflected in a contrary direction upon the object. The rays in the pencils proceeding from the object were to pass through a lens in the tube, as in the former construction; and by converging with greater accuracy to points on the screen, they would have produced a more correct image than that which results from refracted light alone.

SEATS OF INDUSTRY.—XXXVIII.

MELBOURNE.

BY WILLIAM WATT WEBSTER.

Only seventy years have elapsed since the discovery of that portion of Australia called Victoria, and only thirty-eight years since the first permanent settlement of colonists was established on any part of it. As early as 1802 a faint effort was made to plant a town on the spot where Melbourne now stands, but it was soon abandoned. A colony, consisting of 1,030 individuals, of whom upwards of 700 were convicts, was founded at Sydney in 1788, and made rapid progress. Offshoots from this settlement began the colonisation of Tasmania, till lately known as Van Diemen's Land, and the earliest permanent settlers in Victoria came from the latter colony. In 1834 a small company from Tasmania, under the leadership of Mr. Thomas Henty, located themselves at Portland Bay, 234 miles from Melbourne. At that date there was not a house nor a garden on any portion of the ground on which Melbourne and its suburbs are built; but in the following year two parties from Tasmania landed at Port Phillip and took possession of the place. The first to arrive was John Batman and his family, and before many months passed he was joined, much to his chagrin, by John Pascoe Fawkner and another company of Tasmanians. Quarrels immediately broke out between the two pioneers, which had the effect of attracting other colonists to the district, and by 1836 a village of rude huts was built, which

contained a population of 224 souls. Fawkner's party raised wheat on five acres of the site of Melbourne. The first land sales took place in 1837, and in the same year the young town was named after Lord Melbourne, then British Prime Minister. In rapidity of growth Melbourne rivals all the towns of America, not even excepting San Francisco. By 1841 it contained 11,738 inhabitants, and in the following year it was incorporated as a town. The population nearly trebled itself within the succeeding five years, it having numbered 32,875 in 1846. In 1847 Melbourne was made the seat of a bishop, and in 1851, on Victoria being formed into a separate colony, Melbourne was fixed upon as the capital, at which date, including its suburbs, the city contained 77,345 inhabitants.

Up till the year 1851 the progress of Melbourne, however extraordinary, was quite normal in its causes. Within sixteen years from the landing of John Batman and his family on the banks of the Yarra-Yarra, a town had grown up that surpassed Sydney in population and extent; that had handsome streets, great warehouses, and busy shops; and that carried on a thriving trade with the sheep-farmers of the interior, and with the mother country, to which it exported large quantities of wool, and from which it imported English produce and manufactures for the use of the colonists. All these remarkable changes had been accomplished gradually though rapidly, and without the aid of any unusual occurrence contributing to its advancement.

But an event now took place that gave an instantaneous impetus, and has exercised a great and permanent influence on the fortunes both of the colony and of its capital city. In February, 1851, gold was found at Bathurst, near Sydney, and in September of the same year rich gold-fields were opened at Ballarat, within 100 miles of Melbourne. No sooner did the news that gold mines had been discovered in Australia reach Europe than adventurers from all countries and of every class flocked to Melbourne, and the stream of emigration flowed on with increasing volume for several years. During one week in 1851 about 10,000 persons landed in Melbourne. The total imports of Victoria for that year only amounted to £1,056,437, but by 1856-57 they rose, under the influence of the gold fever, to £15,182,530. In 1851 the total population of Victoria only numbered 90,000, but in consequence of the rush to the gold-fields it had increased by 1854 to 232,000, and in September, 1867, it amounted to 653,744, of whom 369,103 were males, and 284,641 females. Melbourne contained 77,345 inhabitants at the end of the year 1851, and nearly 90,000 in 1856. By 1861 the population of the city had risen to 125,000, and by 1865, inclusive of the suburbs, to 140,000. From an analysis of the census for the latter year we learn the following particulars:— The city of Melbourne proper then contained 23,700 inhabitants; East Melbourne, 2,000; North Melbourne and Carleton, 16,400; Fitzroy, 11,800; East Collingwood, 12,600; Richmond, 11,000; Jika Jika, 8,200; South Yarra and Prahrm, 13,000; Emerald Hill and Sandridge, 12,400; St. Kilda and Brighton, 11,300; Doutta Galla and Keilor, 3,000; Boroondara and Heidelberg, 5,700; and Cat-Paw-Paw, 6,000. In 1867 the total population of the city and suburbs amounted to 163,308, of which Melbourne proper reckoned 48,500.

The produce of the gold-fields of Victoria in 1852 exceeded a total of 4,247,000 ozs., and they have never since yielded so large a quantity of the precious metal. In 1856-57 a great commercial crisis, which resulted in all but universal bankruptcy, occurred in the city, in consequence of the excessive importations coinciding with a diminished supply of gold, and Melbourne has since undergone many similar, though less general trade vicissitudes. The best result of the gold discoveries was the rapid colonisation of the country, and the consequent development of its agricultural wealth. Perhaps no more graphic and trustworthy account of the changes produced in Melbourne through the influence of the gold discoveries is to be found than in the following remarks from the pen of Mr. Thierry, an old Australian judge. "A more striking contrast," he says, "could not well be furnished than the appearance Melbourne presented when I was there in 1845, and afterwards when I visited it in 1856. In 1845 Bourke Street contained but a few scattered cottages, and sheep were grazed in the thick grass then growing in the street. It was only known to be a street in that year by a sign indicating 'This is Bourke Street.' In 1856 it was as crowded with buildings, and as thronged and alive with the hurrying to and fro of busy people, as Cheapside at the present day. Two branches of Sydney banks supplied the district in 1845 with banking accommodation that only occupied them with business a few hours each day; in 1856 eight banks could scarcely meet the pecuniary exigencies of the community. In the principal street—Collins Street—there was, in 1845, but one jeweller, who displayed a scanty supply of second-hand watches and pinchbeck brooches, in a shop similar to those in which pawnbrokers display their articles of used-up jewellery in the bye-streets off the Strand. In 1856 might be seen in the same street jewellers' shops as numerous and brilliant as those that glitter in Regent Street. The harbour of Hobson's Bay on the morning on which I left it in 1846 contained two large ships, three brigs, and a few small colonial craft. In 1856 the same harbour was filled with about two hundred large London and Liverpool ships, and countless other vessels from America, New Zealand, and other parts. In 1845 there was little more than one clergyman of each religious denomination. In 1856 a numerous clergy of the various denominations officiated; the two principal, Church of England and Roman Catholic, presided over by bishops of their respective creeds. In short, in size, in wealth, in numbers, in varied social enjoyments, the humble town I had quitted in 1846 had been transformed in 1856 into a splendid city, and presented such a transition from poverty to splendour as no city of the ancient or modern world had heretofore exhibited in a corresponding period."

But even this striking contrast does not fully bring out the progress that Melbourne had made by 1856. In the preceding year the Parliament Houses of Victoria, which were estimated to cost £400,000 and are still unfinished, were commenced, and a University with an annual endowment of £9,000, and which now possesses valuable scholarships and exhibitions, was opened. The University possesses a large building, surrounded by extensive grounds, and in 1861 no less than 105 students attended its classes in law, civil engineering, and the arts. In 1859 the Post-office, a magnificent edifice in the Italian style, was completed and opened. Melbourne is well supplied with water, conveyed from a distance of eighteen miles by means of the Yarra-Yarra water-works, and distributed to all parts of the city. Four lines of railway converge at Melbourne. Nearly the whole export and import trade of Victoria is carried on from Port Phillip, an inlet of the Pacific Ocean, which is about forty miles broad from south to north, and at its greatest extent, from east to west, is about forty miles long. This fine basin is only two miles wide at the entrance, which is formed by two projecting promontories called the heads, and is calculated to cover an area of about 800 square miles. In 1861, 3,598 vessels of an aggregate burden of 1,090,002 tons entered and cleared the ports of Victoria, and of these no fewer than 3,023 vessels, representing 995,082 tons burden, entered and cleared the port of Melbourne. The total value of the imports, including bullion and specie, in 1864 amounted to £14,974,815; in 1865 to £13,257,537; and in 1866 to £14,771,711. Among the miscellaneous articles imported the principal consisted of grain of all kinds, flour, drapery, clothing, boots and shoes, hardware and ironmongery, sugar, spirits, tobacco, tea, wine, and opium. The total exports for 1864 reached a value of £13,898,384; for 1865 of £13,150,748; and for 1866 of £12,889,546, including for each of these years respectively gold bullion to the value of £6,206,237, £6,190,317, and £5,900,987. Besides the bullion gold specie was exported from Melbourne to the value, in 1864, of £1,627,872; in 1865 of £809,269; and in 1866 of £961,493. Next to gold the most important article of export is wool. In 1851 the quantity of wool shipped at Melbourne was 16,345,468 lbs. In 1864 the exports of this product were valued at £3,250,128; in 1865 at £3,315,109; and in 1866 at £3,196,471, the latter amount representing 42,390,978 lbs. Of hides, which form a large item in the exports, £94,551 worth were shipped in 1864, and the exports of cattle and sheep in the same year reached a total value of upwards of £170,000. Within the past few years an important trade has been carried on from this port in preserved meats, which seems likely to attain great dimensions. Numerous large companies are engaged in cooking and tinning beef and mutton, both in Victoria and in the other Australian colonies, and this branch of industry is capable of being extended to a much greater degree than it has yet been. The commerce of Melbourne has been almost stationary for some years.

Melbourne is chiefly built on the north bank of the Yarra-Yarra, at a point about nine miles by water and two miles by land from its confluence with the bay of Port Phillip. Vessels drawing twenty-four feet of water can come up to the mouth of the Yarra-Yarra, but owing to bars and shallows the river is not generally navigable by ships of more than sixty tons burden. Williamstown, the port of Melbourne, is situated near the mouth of the Yarra-Yarra. The site of Melbourne is so low that it is liable to be flooded by the river, which occasionally overflows its banks in the wet season, and during heavy rains the streets are sometimes impassable to foot passengers. Throughout the greater part of the year the gutters are filled with water. The houses are mostly built of brick and stone, and the streets are wide and regularly laid out, Collins Street being one-third wider than the celebrated Broadway of New York. Melbourne contains many handsome buildings, and is adorned by a large number of noble institutions. The Free Library is a magnificent room 230 feet in length, 50 feet in width, and 34 feet high, the sides of which consist of numerous small rooms, in each of which are placed books relating to one or two subjects. In 1867, 92,457 visits were paid to this library, which contains 53,000 volumes. Adjoining the library is a valuable exhibition of native and foreign art, and near to it an hospital which expends about £18,000 annually and can accommodate upwards of 400 patients. In the Royal Park there is a small Zoological and Acclimatisation Garden, from which many animals—deer, hares, partridges, pheasants, etc.—have been turned loose in the country, and have thriven and multiplied.

PRACTICAL APPLICATION OF THE FINE ARTS.—XV.

By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING (*continued*).

STUDY OF GOOD EXAMPLES—COLOUR—LINE—INDIA-RUBBER BINDING.

Our readers by this time will have seen the various processes required in binding a book, whether permanently, to be placed upon the library shelves, or in the temporary cloth cover with which English books, at all events, are protected during the time that they are handed about from man to man, either over the counter of the circulating library, or amongst personal friends. We have described also the materials employed, and we now come to that part of the subject with which it is peculiarly the province of these papers to deal—viz., the application of the general principles of taste, and of the canons of art to the especial materials we have in hand.

Study of Good Examples.—As in almost all art, a study of the works of ancient masters of the craft, and a comparison with what is now put forward, are most useful, and, in fact, almost absolutely necessary. In following out this course of study, for which we have given some considerable amount of material in the illustrations of this and former papers, to which illustrations we shall allude more particularly and individually hereafter, we cannot but be struck, in this as in many other of the so-called art manufactures, with the increased facility for forming beautiful objects, owing to the introduction of new processes, new and improved materials, and a generally increased knowledge of the modes and appliances of art-manufacture amongst the workmen. At the same time no less strikingly marked is the decreased beauty of the work produced. The workman of old, with his coarser materials, his inability to overcome certain difficulties, and his less extensive knowledge, managed to succeed where the modern workman with all these advantages fails. This is due to many causes, and we will endeavour to point out these in the hope that when they are clearly seen they may be to some extent, at all events, guarded against.

One of the causes of excellence among the ancients arises from this very difficulty of execution of which we have been speaking. When a man has the energy and the determination to overcome great, and it would seem to others, overwhelming difficulties, the same energy and determination are increased by the very process, and, moreover, he comes to regard the impossible as a non-existing bugbear. He has found that what many have reported of as scarcely to be accomplished at any rate he has entered upon with comparative ease, and completed only at the expense of energetic exertion carried a little way beyond what is agreeable and gratifying. Such a man is not content with anything short of success, and when he perceived a design did not fulfil the condition that his taste and feeling required, he was never content till he found out the cause of the failure, and had remedied the evil. The work, therefore, of these men came up to their knowledge and taste for the beautiful. Of course the ancients, like the moderns, made many failures; these failures have perished, as they deserved to perish, and as their modern representatives will disappear, after they have accomplished the purpose of their existence by putting money into the pockets of their authors, and by ministering to and increasing the bad taste of the many who, with abundant means to procure the beautiful, have not only no knowledge of wherein the beautiful consists, but imagine it to reside in some unknown qualities which it is not granted to the ordinary mind of man to possess. In these matters, as in those of higher import, the one thing needful is faith; "unless a man believe faithfully" that there is such a thing as a law which governs all matters of taste, and that such a law "is not far from every one of us," but that it resides in us, and is really part of that valuable but rare inheritance to which we all have a claim, but do not all take up our claim—common sense—and, moreover, that this common sense can be enlarged in its sphere and increased in its power by observation and cultivation, there is no hope that he will ever attain to the true standard of really good taste. Occasionally men who have this faith arise, and they work out their own art to a perfection which is astounding to their contemporaries and the marvel of future ages. Of course such men are rare. Many who start on such a good course faint from the want of some one little ingredient required for great success; but their works remain, and the thing of beauty which they produce is a joy for ever to future generations. What we have said here of bookbinding is true not only of bookbinding, but also of all the manufactures to which fine art can be applied, not only of those discussed in these papers, but also all works to which any, the slightest canon of art can be applied. People are astonished at the success of what are called self-made men; the difficulties of their career lay in the first steps they took; afterwards success followed without difficulty. Every child who learns to walk has overcome a greater and more gigantic difficulty than he will ever after have to surpass in order to become the fastest and most perfect walker of his day. Every boy who plods through the crabbed characters and unintelligible and unintelligent orthography of his native tongue has mastered a greater trial than he can ever after have in acquiring the characters and language of an Oriental tongue. So he, too, who has made the first step in producing a fairly elegant and pleasing cover for a small book has overcome the greatest difficulty he will ever have in his advance towards becoming a man of real taste, and a producer of the most thoroughly good work in his own trade; only let him go on and prosper in spite of opposition of false taste and of weariness.

Colour.—In bookbinding, as in all other arts in which colours are in any way employed, the theory of colour must be studied. The laws of this theory are simple, their application universal; but the acquirement of them demands vast experience and careful training. Of course there are some people who are colour-blind; it is doubtful whether even these could not be exercised by constant practice until the faculty of distinguishing some tints, which seems to lie dormant, might not become developed. But the majority who think that they see, but who really are quite unconscious of what Nature places before them, may, without great difficulty, acquire the general principles upon which the laws of colour depend. The laws of contrast, of complementary colours, of the balancing of tints, are in themselves simple; we have constant applications of them in the natural scenes which lie around us, both on a large scale and on a small, in the bird's wing, the petal of a flower, as well as in the distant landscape, the varied and beautiful sky, and bright colours of every foreground, even of a muddy street; we have, moreover, "awful examples" of the violation of these laws in almost all the classes of manufactures which are in daily use. It is not sufficient that colours should be striking. Natural colours are not striking. Patches of light-blue stuck upon emerald-green or reddish-purple will be striking enough to

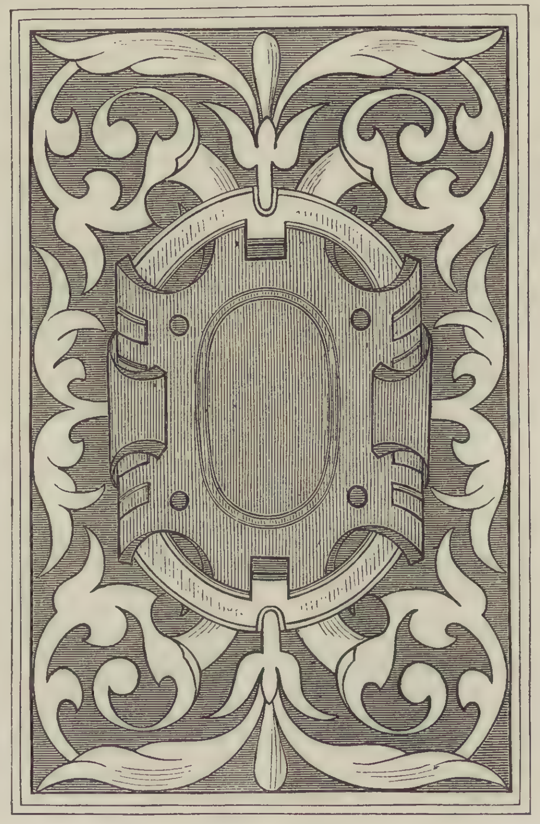
attract a vulgar eye; but these things will not satisfy the requirements of a refined and cultivated taste. Colours applied according to the strict law of complementary colours, with a due calculation of the power and depth of each tint, so that there are not many violent contrasts of light upon dark or dark upon light, will in the end produce agreeable effects. To judge from the specimens we constantly see, many binders think that the more contrasts, and the more violent these contrasts are, the nearer are their designs to the accomplishment of their wishes. A pattern in one light colour upon a dark foundation, or the reverse, with the assistance of a gold line, will be far more satisfactory than a gaudy variety of colour, a confusion of lines, and a meaningless mass of ornamentation. Simplicity of colour is certainly to be preferred in all cases where it is not necessary to have great richness, and even then great variety can only be introduced under the judicious guidance of those who first know how to use simplicity.

Line.—Much of what has been said about colour will apply to line also. A judicious and discriminating study of the works of the old binders will lead to great profit. Here also will be found great simplicity. Straight lines varied by curves, curved lines of all kinds working into one another, not a mere series of bits of circles patched together, but portions of ellipses and all the known mathematical curves, so far adjusted to one another as to seem the results of free-hand imitations of the works of Nature; these are the combinations which form the most pleasing designs. Straight lines and acute angles break the monotony of all these curved lines, the rectilineal and rectangular sides of the cover itself forming a great contrast to the whole.

In the central portion of each cover of more than ordinary pretensions we usually find a space formed with lines that should never be parallel to the ends of the book. On many of the most excellent of the Grolier bindings we have the general outline of an ellipse, a figure introduced even more distinctly in Figs. 2 and 3 on page 88. When the book is of large size and the design elaborate, care is taken to break the line of the ellipse just at the points where the axes would reach to the circumference. This is done with great judgment; at the sides the curves are led on to form a re-entering curve, and so, though in the inner line the eye is carried on almost smoothly, yet in the exterior part of the same figure other forms are suggested and left to the imagination to continue. Where, however, the curve is sharper by causing the continued line to overlap the curve, the line is broken more completely by a curve cutting right through the original line. In Fig. 1, page 89 (a Grolier), the central label presents six sharp points formed by curvilinear angles towards the centres of the long straight lines, and then again, as if to guard against the impression of a sharp point piercing the straight side, a kind of thick *buffer* is interposed, bounded by curves of a different character. A shield with a coat of arms may not ineffectually be used as a centre ornament, provided none of the sides are either rectilinear or approach that form. A diamond shape or rhomboid can be employed also, but the lines around it should be curved and suggest an oval.

The lines of the sides are strengthened by corresponding lines on the edge of the cover parallel to them; but these latter are placed at no great distance within the outer edge, sometimes with scroll-work between, but more frequently simply near the edge, and just within this the straight line is gradually curved off towards the line within it; or curves are brought to equal distances from the straight line, so that if increased in number they would almost suggest this species of line. Specimens of what we mean may be seen upon many of the examples given in this series of papers. At the corners the lines of the sides should not be simply curved round, as this is suggestive of decay in the book, when the sharpness of corners shall have worn away, and the leaves have become what is commonly called "dogs-eared."

It will be seen from this that what is required is a combination of simplicity and variety, a few main lines towards which the remainder point, straight lines by the sides, a central boss, some intermediate curves; but that the way in which these lines are indicated admits of immense variety of curve and combination.



RELIURE DE HARDY-MENIL.

These observations are sufficient for the present. There is much more to be said about the component parts of a good design; but it will be well to digest this first, to observe its application in the many examples which daily come before us, to note where designs fall short of these requirements, and how far this falling short does really detract from their beauty.

It may not be uninstructive, however, while turning away for a time from the further consideration of the leading principles of art in bookbinding, to take up the mechanical part of the process again, and to mention various means that have been proposed as substitutes for the system of sewing the sheets of a book together. The chief of these, which is called "Indian-rubber binding," was introduced by Mr. Hancock, and is not without its advantages for certain kinds of books. The first step in this process, after the sheets have been folded, is to cut the edges with the guillotine, that is used for this purpose, on all sides, back as well as front, which has of course the effect of separating all the leaves one from another. The leaves thus cut are then passed through a kind of gauge, by which the edges in front are brought into the form of a shallow groove, while a corresponding convexity is produced at the back. A piece of strong cloth or canvas is then fastened to the back by means of a cement in which Indian rubber forms the principal ingredient, and the leaves, hitherto without connection, are firmly fastened to the cloth backing and to one another. The union of the leaves having been thus effected, the book is then forwarded and finished in the usual manner. The peculiar advantage of this method of binding is the readiness with which the leaves of any book, however thick and bulky it may be, will open to the fullest extent, and lie perfectly flat, owing to the extreme flexibility of the back. This renders it a most useful mode of binding for certain classes of fine art work, collections of music, maps, engravings, and letters and manuscripts of all kinds in which the writing may be carried so close to the edge of the paper that some part of it would be hidden from view if bound in the ordinary way. Attempts have been made to connect the sheets of a book by metal fasteners in various ways, but none of these possess the advantages of permanence and convenience presented by sewing, and the mode of cementing that has just been described.

GREAT MANUFACTURES OF LITTLE THINGS.—XIII.

CABINET BRASS-FOUNDRY (*continued*).

BY CHARLES HIBBS.

MOST of the articles comprehended in this category consist of two or more pieces, the initiatory form of which has been given to them by one of the two processes we have endeavoured to describe—namely, casting and stamping. The business of the finisher is to put these together, and combine them into articles of utility or ornament, ready for the market. There is, however, yet a third process, by which the parts of some articles are prepared for his manipulation; and without some notice of this our description would not be complete. The process alluded to is that of tube-drawing. We have already mentioned this as a distinct department of the trade, not necessarily connected with our subject, and so far as the manufacture of brass tubes (to be used *as* tubes) is concerned, that assertion is perfectly true. The production of seamless tubes of brass or copper, but principally brass, for the boilers of locomotive, marine, or stationary engines, amounts annually to many thousands of tons; and that of soldered tubes for gas-fittings and other purposes will easily be conceived to be enormous; but neither of these now call for our consideration. We have only to do with the tubular parts of cabinet brass-foundry, and these may be produced upon the cabinet brass-founder's premises. The stems of hat-pegs, the massive-looking rings that slide on cornice poles, the ornamental projecting handles of counting-house doors, etc., are tubes, as are also many other articles whose appearance less betrays their origin. When manufacturers were first led to substitute light tubes for heavy solid rods in different portions of their work, it is probable that they accomplished their object by simply bending and hammering sheet metal over an interior core or mandril, and soldering together the edges of the seam; but this method, which would only produce clumsy and imperfect work, is now superseded by the action of the draw-bench, which imparts a beautifully smooth and even surface, and at the same time reduces the metal to any degree of lightness that may be required. The method of making tubes is now as follows:—A strip or ribbon is cut from the sheet by roller-shears fixed at the proper width apart; this strip is afterwards passed under a pair of rolls which convert it into a long gutter spout, the round surface of the one roll fitting into the hollow of the other. A second pair of rolls, both concave, bend the edges over towards each other, and the rest is done by the drawing tool. This is a heavy block of steel with a hole in the centre, fixed upon the substantial bed of the long drawing-bench. The end of the tube is bent and hammered over in any rough way to pass it through this hole, and is afterwards "dubbed" or "tanged" outwards with a few blows to form a lip for the drawing pincers to hold. These grip it tightly, and being set in motion by a system of wheel and chain work moved by a winch, draw the tube steadily and slowly through the hole, forcing it to take a true cylindrical shape from end to end. The edges are then united by placing the tube in a suitable stove, the seam having been first plastered with wet solder, consisting of grain-brass and borax, as a flux. When cooled, it is again put through the draw-bench to smooth down inequalities, and is ready for polishing up. Should the tube, however, be required for any purpose that necessitates smoothness and accuracy of the interior, such as telescopic sliding motions, etc., it is passed through the tool again and again, a steel mandril being first inserted, which makes the inside as smooth as the outside. One advantage of this method is that the tubes can be made of shapes other than cylindrical by accommodating the hole in the block to the pattern required. They can be made square, triangular, or polygonal, or their surfaces can be ribbed or fluted according to fancy. By giving the nut, with the hole in it, a revolving motion while the tube is passing through, a beautiful twisted pattern can be obtained, and by turning it the reverse way during a second process a diamond ornament is the result. An improvement was introduced twenty years ago which rendered practically inexhaustible the variety obtainable in the ornamentation of tubes. Four rollers working together, the concave surfaces of which formed a complete circle when joined, received the tube after it had been perfected at the draw-bench, and impressed upon it the pattern which had been previously cut in their faces by the die-sinker's art. Very beautiful designs were produced by these means; indeed, the only limit lay in the taste and fancy of the artist.

For some purposes it was desirable to use tapering tubes, the diameter of which gradually diminished from end to end. Many were the contrivances invented to effect this, but none were satisfactory until the idea was hit upon of taking advantage of the ductility of two metals. A pattern of the drawing tool, with its orifice, may be made in any material, and casts are taken therefrom in block tin. One of these is fixed upon the draw-bench, and the tube, previously bent over, and still enclosing a mandril of the required shape, is inserted by its thin end. As the draw-pincers pull it through, the tin slowly and reluctantly expands with the pressure, still retaining and impressing its original pattern upon the tube. These moulds are good for one operation only, but they can be easily re-cast, and the first cost of them is but trifling.

During the first experiment of drawing tubes upon a mandril, it was discovered that the brass adhered so firmly to the steel, that the latter could with difficulty be withdrawn. This gave the idea of imparting strength to the tube, and at the same time effecting a great saving in cost, by drawing a thin coating of brass over an interior tube of iron. As soon as this method came into use, brass became applicable to a variety of purposes from which hitherto its yielding nature, and more especially its cost, would have excluded it, such as picture-rods, desk rails, etc. The massive curved bars which guard the plate-glass windows of shops are internally of iron, cut from the sheet, and drawn into a tube, the resplendent brass surface being only a thin veneer. Stair-rods are of solid iron, plated in a similar manner. The most curious application of the process, however, is to cornice poles, which, when fashion decreed that they should assume the appearance of heavy brazen furniture, were coated with thin brass to the extent only of about two-thirds of their circumference, the part which was out of sight still revealing the honest wood.

We have now arrived at the first process of finishing the articles whose component parts have been thus variously prepared. In the case of stamped work, the first step is to free it from the surplus metal that surrounds the edge of the design, it being necessary to leave a little to spare, in order to ensure a perfect impression. For this purpose a press is used, and a pair of clipping tools cut out the pattern clean at a blow. Some stampings have also to be pierced, the design, when completed, being of open or fret work, some of which is very airy and graceful. Our grandmothers affected pierced work, for decorative purposes, more than we do, as may be seen on many an old cabinet whose key-holes, and plates which support the pendent handles, have perforated designs of great elaboration, if not beauty. Finger-plates for doors, and bands for hanging curtains, were frequently of open work, and were sometimes backed by coloured metals to represent enamel. Where the design was not large, these perforations could be made by punches of different shapes, arranged in a press; but where the sheet of metal to be operated upon was too long for such a process, a method called "book piercing" was resorted to, similar to that which the writer remembers to have seen used in perforating the cards for Jacquard looms. Two plates were prepared by having the whole design cut cleanly through them, and between these the sheet metal was laid, as between the leaves of a book. A series of loose punches fitted into the upper holes, and the whole was then passed between a pair of rolls, which compressed the heads of the punches, and forced them through the intervening sheet.

The operations of turning, filing, screwing, riveting, etc., which form the staple of the brass-finisher's art, are so simple as not to require any explanation. The processes which call for description as being peculiar to the trade are mostly those which deal with the ductile quality of the metal, producing results which to the uninitiated would seem almost marvellous. In a former article on "Buttons," we explained that the tiny metallic ring, over which was stretched the little pieces of white linen to form a covered button, was made in the same way as are curtain rings, and gave a short description of the method. As it forms, however, a sort of representative operation in brass foundry, we will here take leave to describe it again, with such amplification as may be necessary. Any one picking up a brass curtain ring, might imagine that it had been

cast, or that it was a piece of wire bent round and soldered. If, from its lightness, a guess were made that it might be a tube, which it really is, the next puzzle would be that it had no apparent joint. Neither has it; the tube is an endless one, and no breach has ever been made in its circumference. It was first cut from a sheet of thin brass in the shape of a crown piece, and the middle was afterwards punched out of it, leaving merely a narrow circular rim, like the diaphragm of a photographer's lens. This was put under a press, and a pair of tools fitting into each other bent the rim into the shape of a circular gutter. A second and third pair of tools turned over the edges of the gutter to meet, and joined them completely, nor can the line of juncture be detected, except by the most critical examination. The metal has therefore been in some parts expanded, and in other parts compressed, and yet not the slightest puckering is visible upon its surface; it has yielded readily to pressure, and readjusted all its particles to suit the change of form. This facile disposition is taken the utmost advantage of in many another process that may be seen in a cabinet brass-founder's shop. Pieces of metal of the most enigmatical shape gradually assume forms familiar, under apparently the simplest manipulation, and the general impression on seeing brass worked for the first time is that anything may be done with it. Let us follow that heap of metal plates, about the size of the top of a tea-cup, which lie on the bench by the side of a powerful press, through all their stages of development, and see what they will become. First, the workman takes them one by one, places them over the hollow, of flattened circular form, which is cut in his bottom die, and brings down upon them a polished globular punch, which domes them up—in technical *parlance*, "raises" them—and they become so many shallow brazen saucers. Next, they are taken to another press, where another pair of tools deepen the concavity, and make them into half-globes. They will then require annealing afresh, and afterwards they are taken to another press, the bottom die of which has a circular hole cut right through it, with polished upright walls. Through this they are forced by the pressure of a descending punch, till they fall into a box below, by which time they assume the appearance of magnified castor-tops. Then they are subjected to the action of a pair of concave dies, fitting one upon the other, between which they are squeezed into the semblance of hollow flattened balls, with an opening of, say, an inch in diameter, on the upper side. The metal is not creased or puckered in the least degree, and is as smooth as when it was cut from the sheet. Meanwhile, another workman has been dressing up and preparing some cast pieces, somewhat pulley-shaped in form, in a lathe, and has cut round one edge of them a nick with a V-shaped turning tool. Another pair of dies, similar to the last, only a trifle smaller in their concavities, come now into operation. The lower one has a recess cut in the bottom of its hollow, and in this the pulley is inserted, its nicked rim just peering above the top of the hole. The brass ball is then placed over it, mouth downwards; the upper die descends upon it, encircles it, and compressing it all round, forces the edges of the narrowing mouth into the nick of the pulley, thenceforth to hold it with an unrelaxing grip. The press is raised, the combined article is taken from its bed, and there is the familiar door-knob, which perhaps, till now, you had innocently thought was a solid lump of metal. You try to shake it, to see if the juncture which has been effected is sufficiently firm for the practical purposes of a knob: the chances are that it will not move in the least; but if it do, the next process will tighten it, and that effectually. The neck is again held in the lathe, the workman presses for an instant the point of a burnishing tool against the outer lip of the nick, the metal immediately closes its grasp, and the union is perfect. While he has it there, he skims over the rapidly revolving surface with a sharp tool, and takes off the "scale," leaving the knob bright and smooth, ready for the burnisher.

Let us again follow these pieces, which, cut in the first place like the others, as circular discs from the sheet, have been "raised" into the form of shallow patty-pans. They are also "drawn down" through the hole of a lower die, until their sides are upright, and then the bottom is cut out, leaving merely a hoop of metal. This is placed between a pair of tools which are cut into hollowed circular wedge form, and they curve the sides of the hoop outward on both edges, making the circumference a shallow groove. A second pair of tools further compress the metal and deepen the indenture, but there has been first placed between them a little cast ornamental piece, which the squeezed metal lays tight hold of, and forthwith comes out a neat little pulley, it may be for a blind-roller, it may be for the hanging weights of a sliding chandelier. In like manner, surprises await the inquisitive on-looker at every turn. He will see a length of tube being wound upon a short, stout pole like a coil of rope. He wonders why it does not flatten or "crink," and is informed that it has been filled first with sand, to keep it in shape. When the pole is full, he will see a clean cut made with a saw across all the coils, and instantly they appear as cornice rings, all but the soldering of their several ends together. He will see workmen at the lathes deftly turning the ends of bell-pulls, scooping out a cup-like recess, inserting therein a piece of beautiful porcelain or glass, turning over the light metal edge with the pressure of the tool, and enclosing it like a jewel in its setting. Forms of beauty will grow under his admiring gaze, combined of the most unlikely materials, and not the least part of his astonishment will be caused by the quickness with which the whole thing is done, and the dexterity of the educated fingers, that move more rapidly than the eye can follow. He will also be struck with the economical division of labour that seems to prevail in all branches of the industry, and the classification of different kinds of work. Thus, in one shop "tack work" alone will be carried on, which means brass-headed nails, hooks, sash and drawer knobs, and little things of that sort. Each article has an iron screw or spike as a part of its anatomy, fixed there immovably by having been placed in the mould for the melted metal to enclose it, and this constitutes it tack work. In another shop "spring work" is the speciality, that is, any articles in which springs are introduced, as blind-cord racks, cupboard bolts, bell furniture, etc.; and in a very large manufactory each one of these articles would form a separate branch.

When brass articles have been turned, filed, or otherwise dressed, they are ready to undergo the process of dipping. We have said something of this when treating of buttons, and have only to add a description of the peculiar method of "dead" dipping, which produces a beautiful frosted appearance on the work, and enables variety to be given by burnishing or brightening up prominent parts. The secret of dead dipping was first discovered by accident. A dipper had, through negligence, left a quantity of work all night in the "pickle," or cleansing solution, which consists of weak diluted aquafortis; and the consequence was that on immersion in the stronger liquid in the morning, it would not come bright as usual, but presented a dull dead surface like that of ground glass. The effect was pleasing, and dead dipping has been the fashion ever since. The *modus operandi* differs, however, from that hit upon by the careless workman. For bright dipping, a single immersion for an instant in the sharp acid is sufficient. A reciprocal action then takes place, the chemical nature of which we must leave others to explain, but some part of the acid is taken up by the metal, and at the same time some part of the metal is left behind in the acid. In course of time the acid will become so impregnated with brass that its action will be sluggish, in which state it is just in the proper condition for dead dipping. The workman immerses the articles several times in this solution, until the acid no longer "bites" the metal, but rolls off it like water, by which time the frosted surface is produced. After dipping, all articles are swilled, the first time in a vessel filled with water, the second in a running stream; and as, after many swillings, the water in the vessel becomes too strongly tinged with acid, it is taken away to be used for "pickle." An alkaline solution is used for a final dip, in the case of articles whose joinings might accidentally contain a little of the insidious acid, which is thus killed.

The next process is burnishing, which again requires little description. Steel tools are used, instead of the stone ones affected by button burnishers, and these are of various shapes, pointed, hooked, or with "spade" or ball" terminations, to suit the different forms of the work. As the burnisher must have a solid surface to work upon, he requires, in the case of thin stamped work, to be furnished with a lead force, or casting from the die, in order to support it internally in all its parts.

The last operation is "lacquering," which simply means coating the articles with a transparent varnish to protect them from oxidisation. The varnish is composed of seed-lac dis-

solved in spirits of wine, sometimes a little turmeric or dragon's blood being added to give richness of colour. When this is applied, by means of a camel-hair brush, to the warmed bright surface of the metal, the spirit quickly evaporates, and leaves a thin film of the gum behind, which will adhere firmly to the brass, and withstand all fair usage for years. The art of good lacquering consists in coating the surface evenly, so that no smears or joins may be visible, the difficulty being greatly enhanced in the case of large articles, on account of the rapidity with which the varnish dries up under the influence of heat. A great deal depends upon the articles being uniformly heated, and suitable stoves are required for the purpose. The temperature of the lacquering shop is, for this reason, uncomfortably high.

The curiosities of the brass trade are many. One consists in the manufacture of brass rings for adornment, which form the jewellery of the native African. Wherever commerce has penetrated that mysterious continent, there the products of the Birmingham brass-foundry will be found in the most ludicrous connection. Dr. Livingstone described the costume of a Makokolo lady as consisting entirely of brass rings and beads, which she arranged as follows :—Eighteen solid rings, as thick as a finger, upon each leg; nineteen similar ones on the left arm, and eight on the right; besides three rings of copper under each knee, and an ivory ring above the elbow. An order once reached Birmingham for 20,000 dozen of these "bangles," consuming in their manufacture 23½ tons of brass. Rings and coils of thick brass wire not only form the personal ornaments of the African gentry, and the criterion of their wealth, but they are also used as a medium of exchange. Great quantities of a species of money, called "Manilla," were once produced in this country, and exported to Africa, as also brass coins, with rude image and superscription. Should the researches of African travellers prove that a larger part of that continent can be opened to our trade, we may expect "a good time coming" for Birmingham brass-workers.

TECHNICAL DRAWING.—XCII.

DRAWING FOR METAL-PLATE WORKERS (*continued*).

THE term *dome* is applied to the covering of the whole or part of a building. The Germans call it *dom*, and give the name to the cathedral or principal church in a city, although the building may not have a spherical or polygonal dome. From this and other circumstances it is inferred that the term is derived from the Latin *domus*, a house.

The following definition is given by Mr. Peter Nicholson, to whose excellent works we are also indebted for the illustrations of this branch of our subject:—

"A dome is an outer or vaulted roof, springing from a polygonal, circular, or elliptic plan, presenting a convex surface on the outside, or a concavity within, so that every horizontal section may be of a similar figure, and have a common vertical axis. According to the plan from which they spring, domes are either circular, elliptical, or polygonal. Of these the circular may be spherical, spheroidal, ellipsoidal, hyperboloidal, paraboloidal.

"The word *dome* is applied to the external part of the spherical or polygonal roof, and *cupola* to the internal part. Cupola is derived from the Italian *cupo*, deep, whence also our word 'cup;' but 'cupola' and 'dome' are often used synonymously, although perhaps incorrectly. Such as rise higher than the radius of the base are denominated *surmounted* domes; those that are of a less height than the radius are called *diminished* or *surbased*; and such as have circular bases are termed cupolas."

The forms named above, "hyperboloidal" and "paraboloidal," will be understood on constructing figures of a hyperbola and parabola, which would be the vertical sections taken through the axes of the domes referred to, and these domes would be generated by each of these sections rotating on its axis.

Thus, if a piece of cardboard be cut into the shape of the parabola, and a wire or thread inserted so as to form a vertical axis, then if the student, holding this string or wire, blows against the edge of the piece of card, he will, as it whirls round, see the paraboloid or solid parabola generated.

Fig. 672.—*Given the plan of a square dome, and one of the axis-ribs at right angles to the sides, to find the curve of the angle-rib and the covering.*

The axis of a square dome is the vertical line in which the diagonal planes would intersect each other.

Let A B C D be the plan of the dome, and A C and B D the intersections of the diagonal planes. E F is the base and E K the height of the given rib; and the curve line K I H G F the section of the upper surface which comes in contact with the boarding.

The student will realise this if he imagines the point K raised, so that it is over E, the quadrant E F K thus becoming vertical.

Produce E F to k, divide the curve line K F into any number of equal parts, and it will be understood, as the operation progresses, that the more points taken, the more correct will be the result.

Set off the parts F G, G H, H I, I K, upon the straight line F k; the first from F to g, the second from g to h, the third from h to i, and the fourth from i to k. Through g, h, and i draw lines parallel to A D. From the points G, H, I, in the curve of the given rib, draw G G′ N, H H′ O, I I′ P parallel to A D, cutting the base of the rib E F at the points G′, H′, I′, and the half diagonal D E at the points N, O, P.

Take the intercepted parts G′ N, H O, I P, between E F and E D, and apply them successively to the lines parallel to A D on each side of F k.

This is best done by drawing perpendiculars from I, H, G, cutting the lines drawn through g, h, i in n, o, p.

Draw through these points the curve A n o p k.

Measure on the other portion of the lines from g, h, i, the widths $g\ n$, $h\ o$, $i\ p$—viz., $i\ p'$, $h\ o'$, $g\ n'$, and draw $k\ p'\ o'\ n'$ D.

Then the space contained between A K D will be the form of the lead or zinc required to cover the one quarter, A E D, of the dome.

To find the hip-line of the angle-rib, the base of which is E D.

From the points N, O, P, E, draw N Q, O R, P S, and E T perpendicular to E D. Make these lines successively equal to G′ G, H H, I′ I, and E K; and through the points D, Q, R, S, T draw a curve which will be the hip-line.

To draw the angle-rib and covering of an octagonal dome.

Fig. 673 is the plan of the octagonal dome, showing also the given rib.

Let A B C D E F G H be the plan, and let L O K be the given rib—that is, the rib passing to the apex, at right angles to the side A H.

Divide the arc L K into any number of equal parts, as a, b, c, and draw the radius A O.

From a, b, c draw lines parallel to O K, and cutting A O in a', b', c'.

From a', b', c' draw lines at right angles to A O, set off on these the lengths of the perpendiculars in the given rib similarly lettered, measuring from the line L O to a b c. Then through the points M, c'', b'', a'', and A, draw the curve which will be the form of the angle-rib.

Now to find the covering of one side of this dome.

Draw a perpendicular at L, and set off on it the lengths a'', b'', c'', M, measured from the curve of the angle-rib, and through these points draw horizontals.

Intersect these by perpendiculars from a', b', c', and the points so obtained will be those through which the required curve is to be drawn, as in the last figure. The same measurements set off on the horizontal lines from the central perpendicular will give the other side of the covering.

Fig. 674 shows the method of finding the form of the covering without drawing the whole plan.

To find the hip and rib parallel to the longitudinal side of an oblong building, also the covering of the sides of the dome, the plan and rib parallel to the shorter side being given.

Fig. 675.—Let I J L K be the plan, and let A B be the given rib.

Divide the curve A B into any number of equal parts, 1, 2, 3, and draw the diagonals I L and J K.

From 1, 2, 3, draw lines parallel to I K, cutting A G, the base of the given rib, in 1′, 2′, 3′, and passing through G K.

Through the points of intersection in G K draw lines parallel to K L, passing through G E, the base of the required longitudinal hip, in f, e, d, and through G L in h, i, and k.

Make $f\ c$, $e\ b$, and $d\ a$ equal to 3′ 3, 2′ 2, 1′ 1, and draw the curve E a b c A, which will be the form of the hip parallel to

the long side of the plan—viz., starting from E at right angles to K L. We now proceed to find the form of the angle-rib—viz., that of which L G is the plan.

From G, *h*, *i*, *k* draw lines perpendicular to G L.

Make the perpendicular at G—viz., G G′—equal to G B; make those on *h*, *i*, and *k* equal to *f c*, *e b*, and *d a* respectively; and draw the curve G′ L, which will be the form of the angle-hip.

It is now necessary to find the covering of the dome. To find that of the longitudinal side, through G draw A C, parallel distances on the other side of the central line—viz., *h″*, *i″*, *k″*. From F draw the curves through these points, thus completing the development.

Now, to make the form of the whole of this still more clear to the learner, let us suppose the figure carefully drawn to a much larger scale, on a piece of stiff drawing paper or cardboard. Cut with a penknife through the curve A B, through the lines B G and G A, and place the quadrant upright on its edge A G, securing it by gumming a piece of paper under the corner-piece I.

Fig. 672.

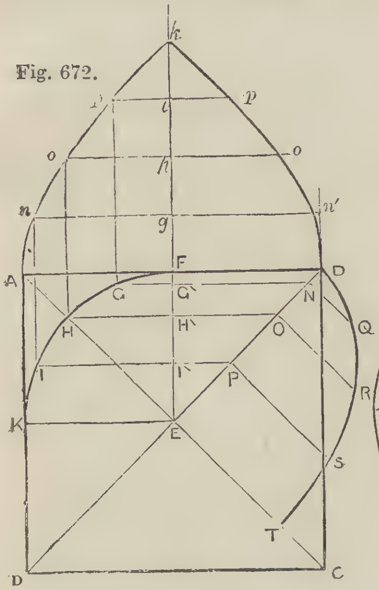


Fig. 674.

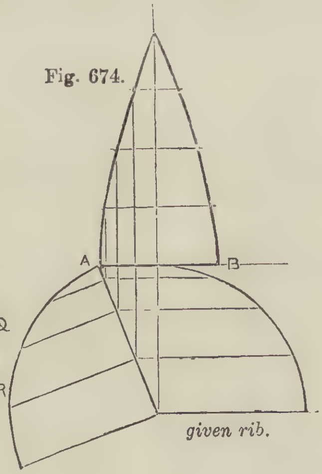


Fig. 673.

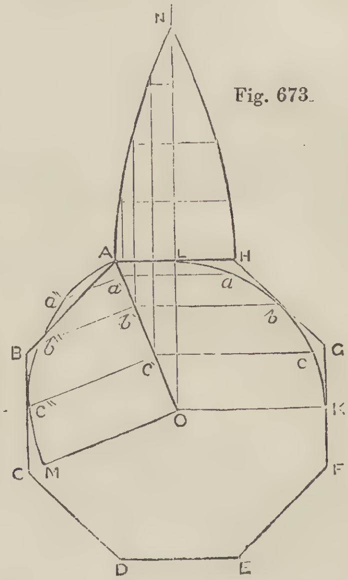


Fig. 675.

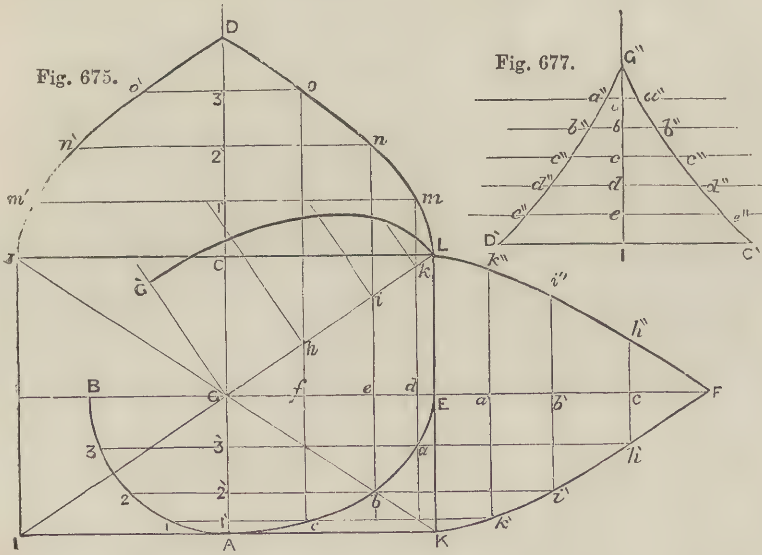
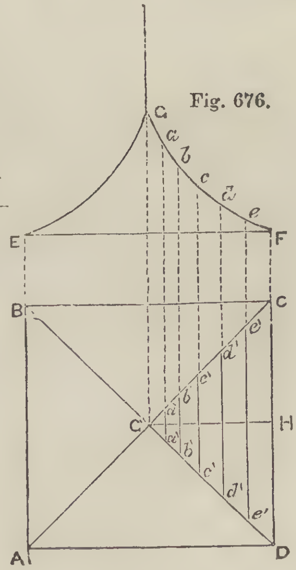


Fig. 677.

Fig. 676.



to I J and K L, and produce it indefinitely; from C mark off on this line 1′, 2′, 3′, D, equal to 1, 2, 3, B on the original rib A B, and through these points draw horizontals, which cutting the lines passing though *h*, *i*, *k* (parallel to K L), will give the points *m*, *n*, *o*. Set off on the opposite of C D, the widths 3′ *o*′, 2′ *n*′, 1′ *m*′, equal to 3 *o*, 2 *n*, and 1 *m*, draw the curves D *o n m* L and D *o′ n′ m′* J, then J D L will be the required covering.

Now produce G E (the line parallel to I K) indefinitely, and from E set off on it the lengths *a*, *b*, *c*, A, taken from the rib E A, thus obtaining the points *a′*, *b′*, *c′*, F, and through these draw lines parallel to K L.

Produce the lines 3′ *a*, 2′ *b*, and 1′ *c* until they meet the lines drawn through *a′*, *b′*, and *c′*, in *h′*, *i′*, *k′*; set off the same

Now cut through the curve A E, and at the back cut half through the thickness of the line G E, and bend the piece A E upwards until it is perpendicular to the surface of the drawing.

In the same way cut through the curve L G′, and the line G G′, and half through the line L G, and bend up the figure L G G, until it is vertical.

Then it will be seen that the points A of the one rib, B of the other, and G′ of the third, will meet at one point, the three lines G A, G B, and G G′ uniting in one perpendicular, and these would then be the forms of the respective roof-trusses.

Now cut out the curves J D L and L F K, and it will be seen that these pieces will exactly cover the ribs in the form required, D meeting F on the point G (in which A and B are also united).

As by this method the curve L G′ cuts into the covering L I J, and there are other little inconveniences arising from making such a model out of one piece, it is advisable to make the three ribs out of separate pieces, and to gum them on the plan, using strips of linen by way of hinges; they can then be raised or laid down flat at pleasure.

Fig. 676.—This figure gives the plan and elevation of a pyramidical roof, the plan of which is square, and the surface of which curves inwardly.

A B C D is the plan and E F G the section through G′, and this would be the form of the truss or rib parallel to the sides.

The angle-rib would, of course, be obtained as in the last figure.

Now to find the form of the covering.

Divide F G into any number of equal parts, a, b, c, d, e, and from these points draw perpendiculars cutting the semi-diagonals G′ C and G′ D in a' a', b' b', c' c', d' d', e' e', and draw the line G′ H.

Now draw any perpendicular, I (Fig. 677), and a horizontal at its lower extremity, and on this set off on each side of I the length I C′ and I D′, equal to H C and H D in the plan.

On I set off the lengths e, d, c, b, a, taken from those on the curve G F (Fig. 676), and through these points draw horizontal lines.

On these, on each side of the perpendicular, set off the widths of the lines on each side of the line G H in the plan (a', b', c', d', e'), and through the points a'', b'', c'', d'', e'' thus obtained draw the curves G″ C′ and G″ D′, thus completing the covering.

The student is urged not to be content with working out the linear drawings given in the present course, but to practise freehand and object drawing. Lessons on the former will be found attached to Drawing for Carpenters and Joiners, for Machinists, etc., which form sections of the complete course of "Technical Drawing" in THE TECHNICAL EDUCATOR.

SEATS OF INDUSTRY.—XXXIX.

BOMBAY (*continued from page* 279).

BY WILLIAM WATT WEBSTER.

DURING the present century the progress of Bombay has been rapid and steady, although local and imperial events have occurred that have temporarily interrupted its trade. In 1803 a very destructive fire broke out in the city, and a still more extensive conflagration, which destroyed 190 houses, and property to the value of £70,000, took place in 1845, but in both cases the damage was soon repaired. The first line of railway constructed in India ran between Bombay and Tannah, a place twenty miles to the north-north-east, and was opened in 1853. In 1816 Bombay contained 161,550 inhabitants, of whom 104,000 were Hindoos, 28,000 Mahometans, 13,000 Parsees, and 4,000 British. By 1861 the population had risen to 566,119, and in 1864 to 816,562, of whom only about one-hundredth were Europeans, and about one-fifth Parsees, two-thirds being Hindoos, and one-fifth Mahometans. The floating population of the city is very numerous, and consists chiefly of Arabs, Goa-Portuguese, Persians, and Parsees, but includes sailors belonging to nearly every country in the world. Of the garrison, which numbers about 4,000, only one-fourth are Europeans. The harbour of Bombay is the most commodious and the safest in India, having good anchorage and shelter for fleets of the largest burden. It is eight miles in diameter, and is the only great inlet in India where the tide rises to a sufficient height to permit of the construction of wet docks on a large scale. The dockyards cover an area of 200 acres. A more extensive trade is carried on between Bombay and China than between the latter country and any other of the Indian Presidencies. The exports to China, which in 1862 amounted to upwards of £6,000,000 in value, consist principally of raw cotton, opium, pearls, sharks' teeth, fins, fish maws, sandal-wood, etc., and the imports into Bombay from that country are chiefly silk piece-goods, spices, and treasure. From Great Britain Bombay receives annually about £8,000,000 worth of cotton and woollen stuffs, cotton yarn, hardware, ironmongery, and other articles, and in exchange sends to this country upwards of £10,000,000 worth of raw cotton and other native wares, and of silk, spices, etc., collected at the port from China and other countries. Besides Britain and China, Bombay carries on a large trade with the ports of the Arabian and Persian Gulfs and the Malabar coast, and with Calcutta, Cutch, and Scinde. The total value of the exports from Bombay in 1862 was £18,622,462, while the total imports amounted in the same year to £9,468,965. There entered the port of Bombay in 1861, 3,163 vessels of an aggregate burden of 170,863 tons, and 2,814 vessels of 169,546 tons burden entered in 1862.

The town of Bombay cannot boast of any striking Oriental magnificence, and in this respect it presents a contrast to Calcutta and Madras. A large portion of the town is old and even mean-looking. It is divided into two parts—the old town, or Fort, and the new town, or Dungaree. The houses are mostly constructed in the same style of architecture adopted by the Portuguese when they first began to build the town within the fortifications—that is, they are built with verandahs supported by wooden pillars, and shut up with Venetian blinds, the upper storeys of the houses projecting over the lower, and the roofs being sloped and tiled. The new town is much larger than that within the walls, and is situated on a low, damp site to the north of the old town. Few of the ground-floors of the houses in the new town of Bombay are above the level of the sea at high water, and for seven or eight months in the year the occupants suffer either from actual inundations or the effects of them. There are many Portuguese and Armenian churches, both in the old and new towns, a few synagogues, and a vast number of mosques and temples. The most remarkable edifice in the city is a pagoda dedicated to the worship of Momba Devi. Bombay is the seat of a Church of England bishop. Among the institutions, other than those already referred to, the Mint and the Elphinstone Institution specially deserve mention.

CIVIL ENGINEERING.—XXIV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

WE have next to take up the subject of stone and masonry bridges. Before, however, considering the bridge itself, it will be necessary to make a few observations upon the *centering*, that is, the timber erection upon which the voussoirs are laid until the introduction of the key-stone enables them to support themselves. An essential feature in a *centre* is that it shall be incapable of undergoing any change in its form in consequence of the weight placed upon it. Its intention is to give to the subsequent structure its designed form; the outline of it must therefore correspond exactly with the form of the arch intended temporarily to rest upon it.

The question has frequently been raised, Is it necessary to commence the support of the voussoirs from their very beginning at the spring of the arch, or to leave them to support themselves until their inclination to slide becomes too great? It may be said in reply that it is not absolutely necessary. It has been proved that, provided their centre of gravity does not fall outside the base, a stone will not slide over the surface of another until the angle of contact has reached from 30° to 45°, according to the nature of the surface; and hence, according to theory, the centering need not commence until the voussoirs have attained this angle of inclination. But this, which is good in theory, is false in practice, expecially for arches of great span: hence it is advisable in order to strengthen the tie-beam, to begin the centering at the springing, although comparatively little weight rests upon the centre until 30° from the horizontal is attained; in some ancient bridges the projecting stones upon which the base of the centres rested are yet to be seen.

An Italian engineer, M. Lorgna, has suggested the arrangement of timbers shown in Fig. 71, for a centre, but it is not a suitable form, as the upright posts A B, C D, being themselves unsupported, can afford no real support to the diagonals a B, b B, b D, C D, which rest upon their haunches.

In order to find how best to combine the timbers so as to afford the greatest amount of support to the voussoirs, it is necessary, first of all, to determine the position of the tie-beam. This may be done as follows:—

From the points A and B (Fig. 72) draw the tangents A T, B T. Bisect B C at O, and draw the line T O, from the intersection of the tangents; the point D will be the position of the tie-beam. Divide A D into two or more equal parts, according to its

length, and let fall perpendiculars to the curve upon the tie-beam; these perpendiculars, $a\ b$, $a'\ b'$, will represent the position of intermediate king-posts. Through the points b, b', draw the lines A b B and A b' C; these will become the position of inclined beams to support the tie-beam at $b\ b'$, and the top of the king-post A K. The remainder of the arc below the tie-beam may be divided into as many equal parts as the length requires,

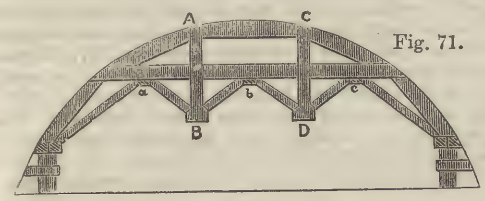


Fig. 71.

and through these points binding pieces, E e, F f, are to be passed, being perpendiculars to the curve, and resting upon the strut. This arrangement with modifications will answer for every form of arch.

We have stated that the voussoirs exercise little or no pressure upon the centering until their surfaces of contact attain an angle of from 30° to 45°. After this point each successive stone will press with increased weight upon the timbers. The relation between the weight of a voussoir and its pressure upon the centering, in a direction perpendicular to the curve, may be determined by the following equation:—

$$W\ (\sin. a - f \cos. a) = P;$$

where W is the actual weight of the voussoir, P its pressure upon the centering, f its friction with the next lower stone, and a the angle which the lower surface of the stone makes with the horizon. Hence, with an average friction—

If a = 34°, P = ·04W.	If a = 42°, P = ·21W.
If a = 36°, P = ·08W.	If a = 44°, P = ·25W.
If a = 38°, P = ·12W.	If a = 46°, P = ·29W.
If a = 40°, P = ·17W.	If a = 60°, P = ·54W.

When the surface of the stone becomes so much inclined that a vertical line passing through its centre of gravity falls outside

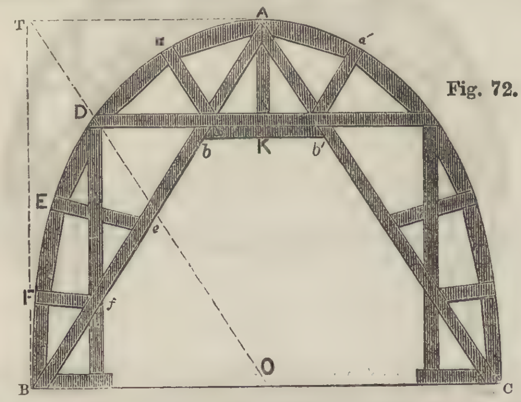


Fig. 72.

the bed of the stone, the whole weight of the stone may be regarded as resting upon the centering.

Perronet omitted the tie-beam altogether, as shown in Fig. 73, imagining that when the timbers were prolonged they found some of their support in the opposite sides of the arch. Such a centering, however, requires great care in the loading.

The centering adopted by the Swiss engineer, Labelye, for the old bridge at Westminster, is a good illustration. It is shown in Fig. 74. Two timbers resting on the abutments incline, and meet at the top of the arch. These form the main supports, and are braced in various directions.

When intermediate bearings can be found for a centre upon the bed of the stream, much of the difficulty attendant upon its construction is avoided. A simple arrangement of timbers with such supports is shown in Fig. 75. An arch of 130 feet span has been erected upon such a centering.

It has to be remembered that in all centering, of whatever construction, it has to be removed after it has fulfilled its duty of supporting the superstructure until the latter can support itself. The weight of the masonry would, however, entirely prevent the removal of the centre as a whole, unless some means be adopted to ease it away gradually from the masonry. The usual course is to insert wedges between the main outer surface of the centre, and the cross-beams upon which the voussoirs actually rest. These wedges can then by suitable appliances be removed one by one, and the cross-beams being then released, the centering can be removed bodily.

Inclined timbers or struts might be made use of for this purpose, but the bearings afforded by them would be neither so numerous nor so uniform as the wedges, one or more of which may be inserted beneath each voussoir.

Smeaton designed a very excellent centering, which was employed in the erection of the Coldstream Bridge. It is represented in Fig. 76, and is seen to consist of a tie-beam with upright posts and diagonal supports. In this case, however, the tie-beam was supported intermediately.

The centering employed by Rennie in the construction of Waterloo Bridge was admirably contrived. The span of each arch is 120 feet, with a versed sine of 32 feet. It was necessary in designing the centering to keep as clear as possible of the tide-way, and Fig. 77 shows how well this was effected.

The voussoirs were supported by cross-timbers which rested upon wedges introduced upon the heads of the inclined beams. The fact that the form of the arches in this bridge has undergone no change, is an evident proof of the excellent manner in which the centres were framed.

In the specification for the centres of the arches of the present London Bridge it states:—"There are to be four complete sets of centres, on which the arches are to be turned; each set of centres is to consist of eight ribs properly braced together, and to be executed according to the drawings; they are to be composed of the best Dantzic, Memel, Riga, or Stettin fir timber, except the springing pieces, which are to be of elm, and the striking wedges are to be of oak of the best quality, entirely free from sap or wave, and cased on the upper and lower sides with fine sheet copper, one-tenth of an inch thick, and to be well greased previous to being put in their places.

"The iron-work to be composed of the very best English iron, and to be executed as described in the drawings; the supports or trussels for carrying the centre to be of the best fir timber, of the quality above described; the trussels and centres when fixed to be firm and strongly braced longitudinally and diagonally, so as to make them firm and secure.

"The covering of the centre for carrying the arch-stone is to be of good sound fir, half timber, seven inches thick, to be carefully laid, properly levelled, and firmly packed and wedged up to the curvature of the respective arches."

It may be noticed here that the specification just quoted from mentions that there are to be *four* complete sets of centres. Now the object in having more than one set, which, when done with at any particular arch, might be removed to the next, is that it would be both unwise and dangerous to remove a set of centering in a bridge consisting of more than one arch, until the piers or buttresses upon which the stone-work abuts are supported upon the opposite side, either by the earthwork in the case of the buttresses, or by a completed arch in the case of the piers, in consequence of the side-thrust exercised by the materials, and which only commences when the centering is removed. Hence, in a bridge consisting of many arches—as, for instance, New London Bridge—it is usual to retain the centres in several finished arches, and to remove them in the first instance from the arch most removed from the unfinished end, by which arrangement the proper amount of support is ensured the piers.

The centering for the beautiful bridge over the Dee at Chester, which consists of a single arch of 200 feet span, consisted of six ribs in width. The span was divided into four spaces by three temporary piers at regular distances built up in the bed of the river, from each of which the supporting timbers spread like a fan towards the soffit, and making a perpendicular to the curve of the arch at the point of contact. The lower ends of these supports rested upon cast-iron shoes placed on the top of the piers, and the upper ends were bound together by two thicknesses of 4-inch plank cut to the form of the arch. On these were laid the covering, $4\frac{1}{2}$ inches thick, which was supported over each rib by a pair of wedges 16 inches long and 1 foot broad, tapering about $1\frac{1}{2}$ inches. Each course of voussoirs

had six pairs of striking wedges. The horizontal timbers of the centre were 13 inches deep, and the six ribs were tied together transversely near the top by bolts of inch-iron. The timber employed was fir, and the quantity required about 10,000 cubic feet.

A useful form of centering is given in Fig. 78. It was employed in a railway bridge over the Ouse, near York.

The piles upon which it rested were based upon the feet of the piers themselves, being inclined outwards.

In the bridge at Neuilly the principals of the centering are only 6 feet 6 inches apart, but they were found to be too weak. Each principal had seven or eight of the timbers composing it split throughout their whole length; others became bent, and their extremities were forced into the faces of the binding pieces. The result was a settlement of the arches. To counteract this as far as possible, the greatest speed was used in carrying on the work, and as it proceeded the centering was strengthened by braces extending from one principal to another, and by placing struts between the opposite courses of voussoirs. The openings in the framing were caused by the timbers not bearing equally against the binding pieces throughout the whole surface of their extremities, and this defect was attempted to be remedied by cutting the ends into a curve. This precaution did not, however, prevent penetration, but it did prevent the splitting of the timber; it also increased the play of the framework, and rendered the centres more liable to change their form.

In forming the centre of a bridge, the weight should be equally borne throughout, and the parts should be made sufficiently strong to support any portion, or the whole of the pressure it has to bear; and it will be found of the greatest value, wherever timbers abut end to end, to employ a socket of iron, as was done in the case of the centres of Waterloo Bridge.

The arrangement for the centering of a tunnel will be treated of under the head of railways.

M. Pitot has gone carefully into the subject of centres. He directs attention, in the first instance, to a determination of the effort which the centre has to make in resisting the pressure at its various parts; and what it will have to bear at different stages of the work, as the various courses of voussoirs are added. He assumed an arch of 60 feet span, of a semi-circular form, with the depth of voussoirs equal to 7 feet, and calculated what should be the scantlings for the centre of such an arch, the timber being of oak. He states that a square inch of oak will safely carry 8,640 pounds; but to be on the safe side he reduces this weight to 7,200 pounds; and the weight of a cubic foot of stone being taken at 160 pounds, he shows that each rib or principal would have to sustain a weight of 707,520 pounds.

This is, however, too high in practice, because no arch of a span of 60 feet would ever require a depth of voussoirs of 7 feet. Besides this, it has already been shown that the voussoirs exercise little or no pressure upon the centre until their joints assume an angle of 30° with the horizontal. This latter fact, therefore, immediately reduces the entire weight upon the centre by one-third of the whole mass, and we are consequently quite safe in taking the effective pressure of the voussoirs as equal to about 500,000 pounds resting upon each rib.

The dimensions of the timbers of each rib were as follow:—The exterior curve, corresponding to the intrados of the arch, was in several lengths, no part less than 12 inches wide, and 6 inches thick, framed and bolted together. The horizontal tie-beam consisted of one main beam extending across the entire span, strengthened in the central part by a second beam. Each of these was 12 inches square. The king-post was 12 inches square; the upper struts 10 inches by 6, and the lower 10 inches by 8.

A centering of these dimensions, constructed of oak, would afford a practical strength equal to upwards of 3,250,000 pounds, which we have shown is very far in excess of the weight it would be required to bear. It is true that we have assumed in the above that the timbers are so placed as to support the weight perpendicularly; but as this is not the case, we must reduce the effective support rendered to the arch by such a centre to about 2,850,000 pounds, or more than four times what is required of it.

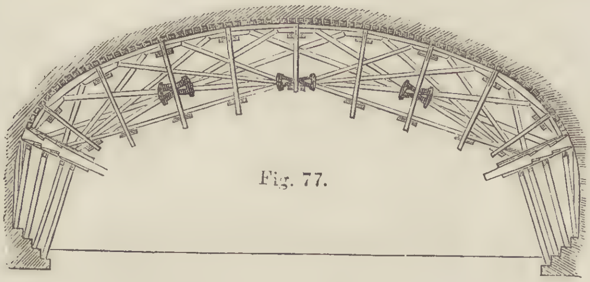


Fig. 77.

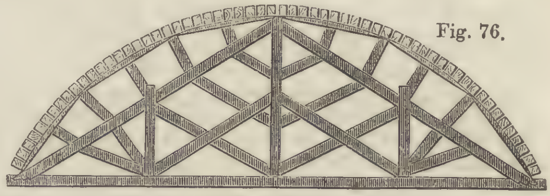


Fig. 76.

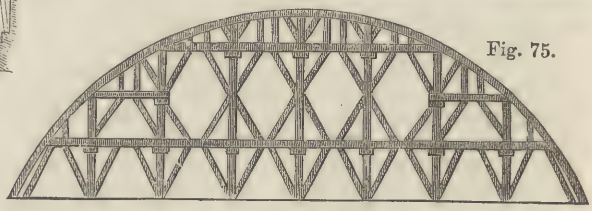


Fig. 75.

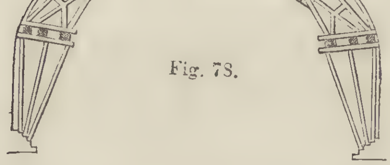


Fig. 78.

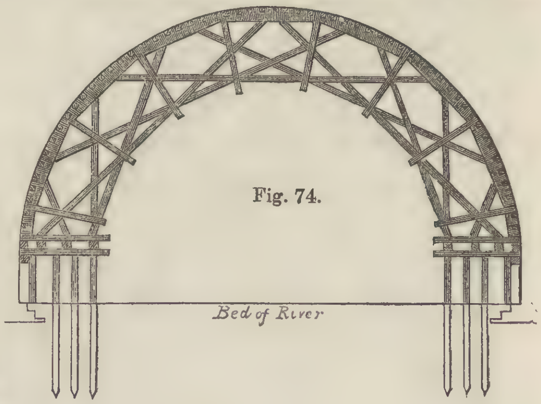


Fig. 74.

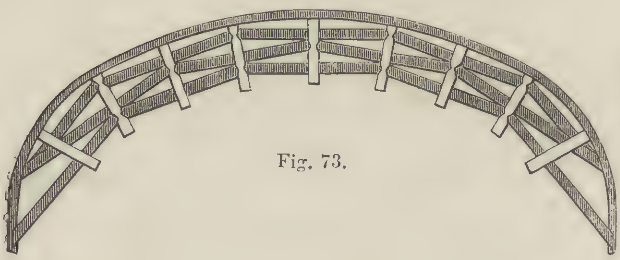


Fig. 73.

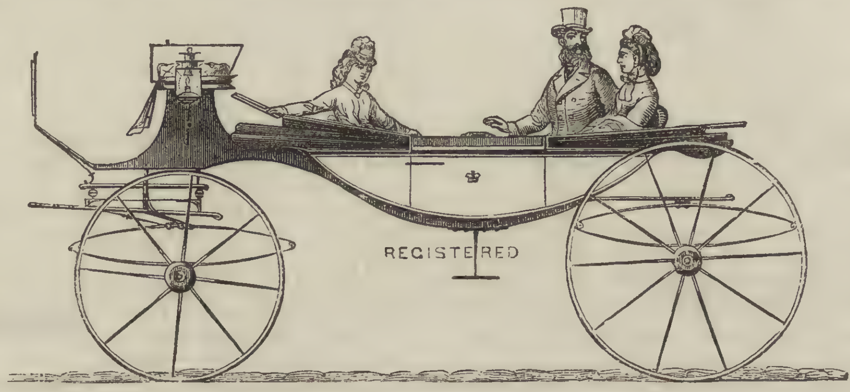
ENGLISH CARRIAGE-BUILDING.—V.

BY A LONDON COACH-BUILDER.

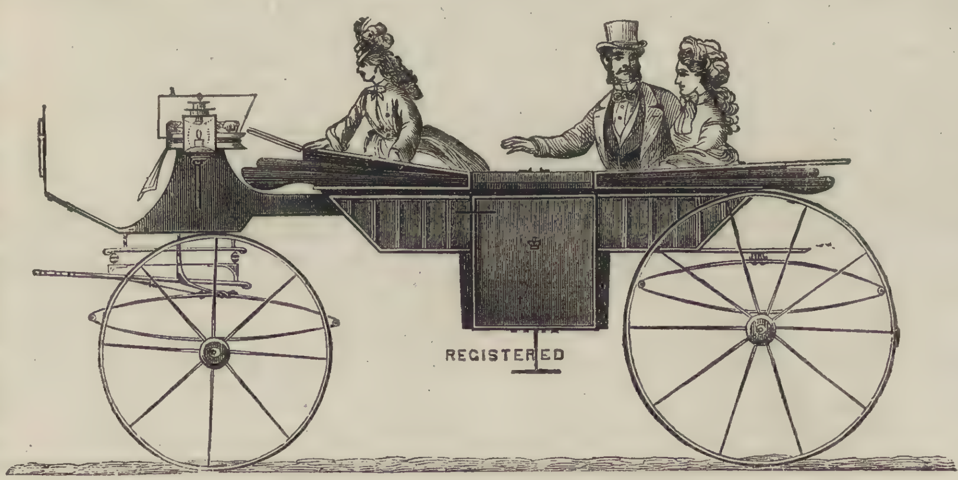
THE LANDAU SOCIABLE.

In giving all the detail of the construction of a carriage, we have chosen the brougham for illustration, this being the national carriage; but our observations would be incomplete if we did not also give some details of the landau sociable, which is becoming more and more popular, and is, in fact, fast assuming the position of the brougham.

This elegant description of carriage is built in two distinct forms, one of which exhibits the latest development of graceful curves and gently flowing sweeps; the other, a series of straight lines and sharp angles. In the illustrations we give of the canoe and the square-shaped landaus it will be seen how entirely different are these two carriages in form, one being constructed according to general principles of taste, the other according to prevailing fashion. Not long ago the canoe-shaped landau was said to present the very lines of beauty, as regards carriage-building, in the highest perfection; to-day the square-shape is spoken of in similar terms. This violent change of opinion cannot very well be pronounced a higher development of taste. The fact appears to be that carriage-building, like the plastic arts, is capable of every variety of form, and so long as that form be expressed according to the laws of harmony, it will convey a pleasing effect to the eye of the beholder.



CANOE-SHAPED LANDAU—OFFORD'S PATENT, REGISTERED.



SQUARE-SHAPED LANDAU—OFFORD'S PATENT, REGISTERED.

It will be unnecessary to say that in constructing this or any other description of carriage, the working drawing is first placed on the canvas in the manner we have described respecting the brougham; but the construction of one is altogether more elaborate than the construction of the other. As the landau is intended to serve as a family carriage, it is necessarily larger than the brougham, and to be made properly should never be constructed to run with less than two horses. It should be very commodious inside, and the front inside seat should be as convenient as the hind one; but as it is intended to serve both as an open and a close carriage, the framework of the body, instead of being carried from the floor to the roof in the solid, is only so constructed half-way up, the whole of the upper part being hinged on to the lower by means of joints specially constructed for the purpose.

These joints are furnished with long arms to which the different parts of the light expanding framework of the head are fixed, and a considerable amount of skill is required to adapt these parts, so that when the entire mechanism of the head is completed it shall present a perfect appearance open or closed.

But what gives this description of carriage a speciality of its own is the many contrivances which have been introduced for lowering or raising the head. The old and simple plan of effecting this, by means of outside joints, came to be regarded by many as not worthy of this mechanical age, the objection to it being that if the head were required to be raised or lowered whilst the carriage was on the road, it was necessary that the coachman should get down from his seat and leave his horses for the purpose, and that if the horses were restive or high-spirited, an accident under such circumstances might easily occur. It was highly desirable that such a possibility should be avoided if practicable, and a deal of ingenuity has since been expended on the subject; but to give a detailed account of the many different contrivances that have been introduced of late years would occupy far more space than could be devoted to the subject in these pages, and it would be invidious for any one connected with the trade to pronounce upon the merits of either. For many years past, inventive genius in the carriage trade has been directed to this particular subject; invention after invention has been introduced, and, to do the inventors but scant justice, they each have a rooted conviction that their own contrivance is the best.

For a long time the object aimed at was simply to enable the coachman to raise or lower the head without dismounting from his seat, and by the adjustment of a series of levers or pulleys and cog-wheels, which were acted upon by means of a winch fixed at the side of the driver, this object was accomplished in two or three different ways. But, not satisfied with this, other inventors sought after a means of obtaining automatic action, such as should enable the riders themselves to open or close the head with the greatest facility, quite independently of their servant. Such an object could only be obtained by means of

springs, but the extreme difficulty of so adjusting them as to ensure uniform action presented a difficulty not easy to overcome; but when inventive genius is once thoroughly awakened, and set on the right track, it is astonishing with what indifference it treats so-called impossibilities. Spring action has been accomplished in a variety of ways, and appears so far

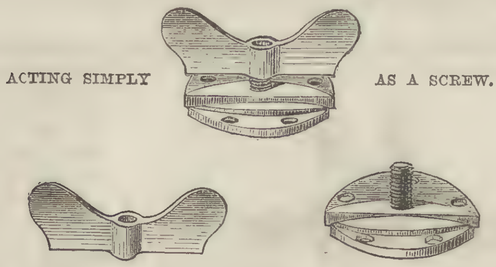


Fig. 10.—PATENT INSIDE LANDAU HEAD-LOCK (1).

successful that it is now being largely adopted, and in our illustrations the extreme facility with which this is effected will be readily seen, the slightest touch from the hand of a lady being sufficient for raising or lowering the head. The drawing showing this has been kindly supplied to us by Mr. Joseph Offord, who, perhaps it will be needless to say, applies this action to landaus of his build; it is necessary, however, to say that by a very neat and simple contrivance of his own, this automatic action of landau-heads is rendered still more effective than it otherwise would be.

When the two divisions of the head are thrown up it is necessary that they should be held together. The old plan of effecting this was by means of what are technically called outside head-locks, which were placed at the point of meeting across the roof. These were not only unsightly, but difficult to get at, and for greater convenience inside head-locks were subsequently substituted; but the difficulty of drawing the two halves of the head to their proper bearing by means of these, so as to render the joint watertight, still presented itself. To avert this difficulty, and to enable the occupants to open or close the head with the greatest facility, Mr. Offord invented and patented an inside screw head-lock, which adapts itself to its work by drawing down the head of the vehicle gradually and with certainty. This lock is easily worked by a thumb-screw which draws the two parts of the head firmly together, and presents the best means of securing against the penetration of wet, and the liability of becoming loose with wear. The extreme simplicity is seen in the figures here given to illustrate this contrivance. Fig. 10 shows how it acts simply as a screw. Fig. 11 presents it with the additional advantage of binding or holding the head together, as well as drawing it down. It may

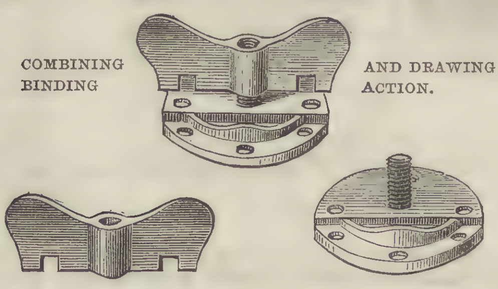


Fig. 11.—PATENT INSIDE LANDAU HEAD-LOCK (2).

be useful to the trade to know that this patent invention is supplied by Messrs. Lowe and Sleigh, of Birmingham.

The landau in its most improved form combines more than the advantages of three distinct vehicles—a close carriage, a barouche or half-headed carriage, and one entirely open. We say it is more useful than the three separate carriages, and for many reasons. It takes up only the room of one—a most important point in town, where space is limited; it costs but little more than one; but the greatest advantage of all is that you have an equivalent to the three *wherever* you happen to be—a matter of no small moment in our constantly changing climate.

Great care and skill are needed in constructing the heads, in order that they may fall flat and level with the elbows, instead of standing up obliquely, about level with the heads of the riders.

Heads of landaus, if made on the old-fashioned principle with outside joints, must have the hoop-sticks and hinges made very strong, as the coachman invariably opens or closes them from one side only, thus throwing a great strain upon the opposite side, which requires to be very strong to prevent a fracture. This danger is obviated by the self-acting heads, as the springs act upon all parts equally in all positions. In fact, the sooner the primitive method of long outside joints is dispensed with, the better.

Before terminating our remarks with reference to four-wheeled carriages, there are various items which require to be noticed. In the matter of steps no definite instructions can be given; experience and ordinary intelligence will generally surmount all the difficulties in this direction.

Steps which are opened and closed by the action of the doors have become very general of late years. The one which is worked by means of rods attached to a slide underneath the body, known as "Offord's patent," is in almost universal use. As a rule, for paved towns, the distance from the ground to the step should be about four inches more than the distance from the step to the floor of the carriage. If the vehicle is for use in country places, it is better to let the step be midway between the ground and the floor. The well-known step with a cover attached to the bottom of the door is not a bad contrivance, and what is technically called a "grid-iron step" is the simplest kind of all, but as it has no protection from the dirt it is not a favourite with the ladies. Lamps to close carriages should be so placed that the top shall be level with the roof. As a rule, the tops of dash-boards should be the same height as the driving-seat rail. The most suitable length for poles is nine feet from the front of the splinter-bar to the tip of the pole. The elaborate dress carriages hung with braces upon a C and under-spring perch carriage require so much skill and practice in their manufacture, that it is impossible to give ample directions for their construction in a work like this. Some years ago it was thought that no carriage could be made comfortable unless it was hung upon the old-fashioned perch carriage with braces, but it was found that by the introduction of india-rubber specially in the ends of each spring, what are technically called elliptic spring carriages (which are, of course, much lighter in draught and less in cost) can be made extremely pleasant in motion.

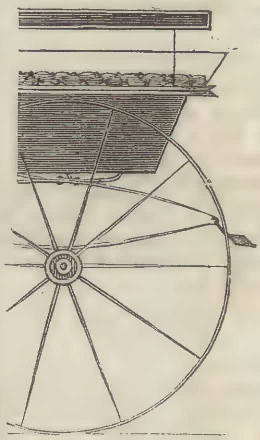


Fig. 12.—MUD SCRAPER.

The rattling so constantly complained of in carriages can in a great degree be obviated, by placing pieces of india-rubber so that the doors shall press upon them when closed. It is a good thing also to have india-rubber at the bottom of the doors for the windows to drop upon when let down.

The difficulty of protecting carriages from the dirt has been recently met by placing what is called a "mud scraper" just at the back of the hind wheels. It is formed of a piece of india-rubber about three inches square and a quarter of an inch thick, held in position by a short iron rod attached to the end of the hind spring, as shown in Fig. 12. An extra amount of india-rubber can be applied, to make a carriage suitable for invalids, by means of "Offord's patent blocks" placed on the top of the springs.

There are, of course, many kinds of carriages not described in these articles; indeed, their name is legion, and it would take volumes to give an account of them; to do so would neither be interesting nor instructive; but no gentleman's establishment would be considered complete without a vehicle of some sort.

The significance of a carriage is indeed great. To set it up

or put it down means sounding a challenge or beating a retreat in society. Who shall ever know the strivings of some to get at this distinction, or the agony of others at being compelled to abandon it? A carriage confers a sort of title. Who has not heard of certain among his neighbours as "quite carriage people," or the definition of respectability as "keeping a gig," or more cleverly, "I guessed what would happen when I saw that stylish turn-out at the door?" With prudent people the sure sign of substantial success is sending a cheque to the coachmaker. It is then certain that Cinderella's pumpkin has at last been changed into the longed-for carriage and pair, or it may only be the useful two-wheeler; and it may be worth while, before closing these papers, to say something on carts, of which there are very many varieties. We must therefore make some selection, and we think we cannot do better than choose that description of cart most generally sought after, and which recommends itself both for purposes of pleasure and profit.

We know of no other description which so effectually fulfils these requisites as the one we here illustrate. It is light in form, pleasing in style, capacious in its internal arrangements; very well adapted for speed, will do well for railway work, carry plenty of luggage, and is equally available for sporting purposes; in fact, it may be recommended for either business or pleasure as a very useful and creditable turn-out.

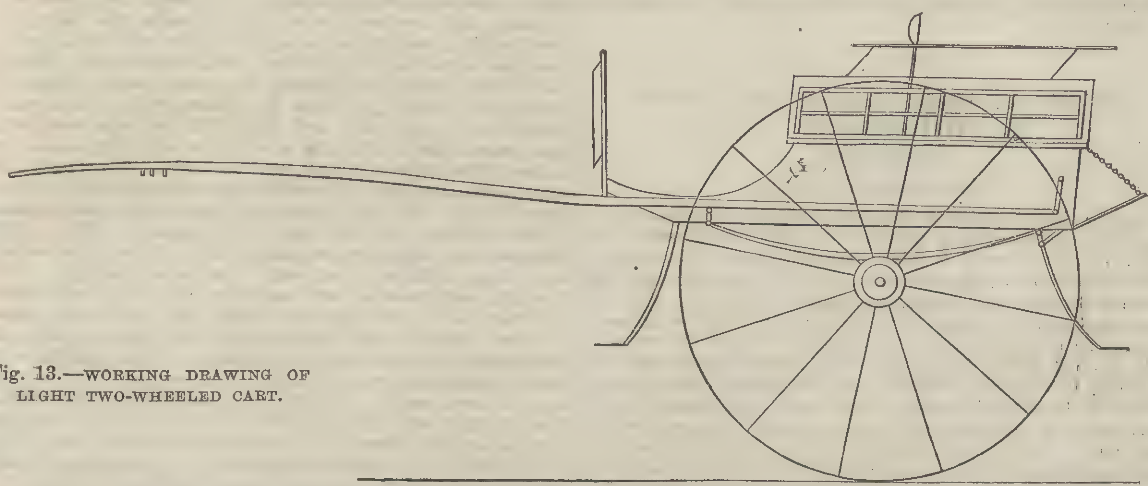


Fig. 13.—WORKING DRAWING OF LIGHT TWO-WHEELED CART.

The make and finish of such a cart may be according to the requirements for which it is intended to adapt it; if, for instance, it is only wanted for rough work, the shafts need only be of ash, the dash and wings may be of wood, a common axle will serve in place of a patent one, and such accessories as lining can be dispensed with altogether. Both the body and wheels may be made with a view rather to strength than beauty, and the process of painting need not be so elaborate as that we have described as essential for the brougham. But such a description of cart is at all times better adapted for a high wheel than a low one, and is therefore more suitable to a horse sixteen hands high than for one of smaller breed: we should recommend, therefore, that such a cart should be made full size, with a wheel 4 feet 8 inches high. Some people have a fancy for wheels even higher than this, but, as a rule, excesses should always be avoided, and we know not where this rule should be observed more strictly than in carriage-building, whether it relates to two or to four-wheeled vehicles.

If an amateur with some mechanical genius wished to try his hand at carriage-building, he might easily construct such a vehicle as this himself; the body is simple in form, and easily framed together; the manner of fitting the shafts and springs is well denoted in the drawing (Fig. 13), and all the necessary fittings can be purchased ready to hand.

For his special benefit we will here furnish a few necessary particulars. The body should be framed of sound ash, the part above the seat-line being made open, with an iron rail running up the front, along the top, and down at the back end of the body. The length of the body at bottom should be 5 feet 2 inches, and the depth of boot-side 14 inches; height of rail framework above boot 9 inches, length of shaft from front of dash to point 6 feet 2 inches, and width of shafts between points 23 inches. The seats should be made to shift, so as to adapt the cart for two or four passengers, and the width of seat-room should be sufficient to allow two persons to sit on each seat with ease and comfort, and to allow plenty of elbow-room for the driver. For this purpose 3 feet 4 inches will be found ample. The axletree should be $1\frac{3}{8}$ inch in thickness, and the length in proportion to the width of the body.

We have said that ash shafts can be attached to such a cart as here described, but we would recommend lancewood, as this timber adds great elasticity to the cart, and a proportionate amount of comfort to the occupants, and to adopt a patent axletree will well repay the expense that would be involved over and above the cost of a common one.

In conclusion, a few words of advice may be useful, and even profitable to carriage owners. First, there is no article which justifies the proverb, "A stitch in time," so well as this; and we would say to a friend, "Always keep your carriage in good repair." It is a luxury necessarily of so costly a nature, that it is exceedingly desirable to keep down the expense of maintenance as much as possible, and this cannot be done better than by avoiding general repairs, and the way this may be done is by having the vehicle periodically overhauled. If the paint be slightly impoverished, it fails to protect the timbers or the iron-work in the manner they require to be protected, and wet may expose one to rot and the other to rust; one bolt or screw may be broken or displaced, which causes an extra strain upon the next, and the next, and the parts which they should hold in position get out of gear; and as each part is but the part of a whole, the whole may be more or less injured by the manner in which one part supports or fails to support the other. In the course of long experience we have had ample opportunity of seeing the full justice of these observations, as well as the advantage of the warning they convey to those who have to pay the penalty of neglecting it.

Again, it is highly essential that the coach-house should be dry and well ventilated; moreover, that it should not be in too close propinquity to the stable, or anywhere near a manure heap, for the ammonia rising in steam from one or the other is highly destructive to varnish, as many have found to their cost. When a carriage is in regular use it should always be washed after it is done with, before being returned to the coach-house, and for this purpose a plentiful supply of clear water is essential, together with a good soft sponge and chamois leather. In bad weather, when a carriage gets covered with mud, if care be not taken in removing it, the panels will be scratched, and by a continuance of carelessness on the part of the coachman, the looking-glass surface destroyed. Such a thing as a spoke-brush should never be allowed inside the coach-house of any

one who has any regard for his carriages; it encourages idleness in the coachman, and will soon show the injurious effects of its use on all the timbers and wheels.

When a carriage is not in regular use, but left standing in the coach-house, as it will be sometimes for weeks, perhaps months together, it is a mistake to suppose it does not require attention. By neglect under such circumstances it may sustain more damage than if in daily use, only that the damage will be of a different kind. By being closed up, moth will get into the cloth of the lining; and by not being washed the timbers will shrink and the joints separate; for it must be borne in mind that, however well seasoned timber may be, the absolute absence of all moisture in it would simply mean dry rot. The carriage should therefore occasionally be drawn out, and well aired, and washed. If these hints be well and carefully attended to, the best economy will be effected, the owner will get the largest possible amount of return for his outlay, and his coach-builder need never get into discredit.

We conclude with a word to young British coach-makers on the subject of charges. Somehow the trade has got a very ugly character on this head, and we fear there is some ground for the complaint which is so common. By all means determine to produce the best possible article, but go in for a large business at small profits, and aid the country in securing in the world the best character for cheap and good carriages. A first-rate brougham ought to be sold for 140 guineas, and a landau for 180 guineas.

GREAT MANUFACTURES OF LITTLE THINGS.—XV.

JEWELLERY.

BY CHARLES HIBBS.

It must not be supposed that we are about to indulge in a dissertation on the glowing period of the Renaissance, when the artist craftsman loved to dwell over a trinket of rare device, and enshrine in it, together with gems of price, the priceless gems of his own rich fancy, stamping it with a thought and meaning that should speak to all time, and making for himself a name as imperishable as the material in which he wrought. We are not going to linger lovingly over the triumphs of Ugolino, Brunelleschi, Ghiberti, or Benvenuto Cellini, whose rare skill, tracing a thousand forms of grace and beauty, traced also lines of deep import upon the character of the age in which they lived. Neither shall we speak of those historical jewels of fabulous value, for the sake of which fleets have been launched, armies set in motion, and kingdoms tossed from one master to another. The romance of human pride and passion, in many chapters, for which the bit of shining carbon or the spoil of the homely oyster has furnished the theme, must have no charms for us; nor must we be tempted into the mazes of antiquity by the allurements of a search after the origin of one of the most ancient of all arts. Could we dare to dwell upon the subject, it would, indeed, be found to be a fertile one, and we should perhaps be astonished, if not humiliated, to find how much influence "barbaric pearl and gold" has had upon man's history from the beginning. Ever the symbol of splendour and power, the unconscious stone itself has aided in enslaving humanity; for magical properties have been assigned to it, and it has become the object of superstitious reverence and regard.

To descend into the plainest matter of fact, we have to deal with jewellery as a *manufacture*, giving employment to many thousands of hands, and using up many tons of material. The latest statistics give about 12,000 as the number employed in Birmingham alone, directly or indirectly, by this flourishing industry. Of course a large part of the vast production is for export, and equally of course, not much of it is composed of the true precious metals that formed the staple of the *orfévrerie* of the Middle Ages. A good deal of it is honest brass, dignified sometimes with more high-sounding names, and technically known in the trade as "compo." A thin wash of gold, deposited by the electro process, lifts it a step higher in the commercial scale, and a still higher position is gained by plating it in the ingot by the older method. The highest, or true aristocratic pinnacle, is held by what is termed "solid," or gold jewellery of the better qualities. It will be convenient to adopt this classification in the few preliminary remarks we have to make about the materials used in the manufacture.

Gold jewellery, as its name imports, is that in which the purest and most imperishable of all metals forms the substance. It must not be supposed, however, that it is always identical with that costly medium which passes current among civilised nations as the measure of value, or that its name is always a guarantee for its metallic nobility. The orders of jewellery-work, like those of society, have infinite gradations, and run into each other in a manner which makes it difficult to draw the line. Thus, the lowest quality of gold work may be vastly inferior to the highest quality of plated; and that, in its turn, may be degraded below the highest level of the plebeian "compo." Standard gold, which implies the quality used for coinage, and which indicates the nearest approach to purity at which the metal can be worked, or made to stand wear and tear, is pretty generally known to be what is called twenty-two carat; *i.e.*, two parts of alloy in twenty-four; that number of carats being contained in an ounce. For the very best kinds of jewellery, no higher quality than eighteen carat is used; and for the many qualities below the highest, the proportion of gold to alloy may shade off into an inappreciable quantity. Some jewellery which is *called* gold has so little of it in its composition that the "aqua" test will fail to detect its presence, and it is difficult to imagine why the make-believe is persisted in. Probably the great bulk of trading gold jewellery is of nine-carat quality, that being the lowest which is entitled to the dignity of the hall mark, but a great deal is made and sold of seven carat, or even lower. Every manufacturer mixes for himself, the usual practice being to obtain grain virgin gold from the refiners, melt it in a small crucible over a bright fire, and alloy it to the point required; some manufacturers affecting a secret in obtaining colour by means of the different metals used as alloys. When cast into small ingots, it is sent to the rolling-mill as required for the purposes of trade. A great impetus was given to the manufacture of gold jewellery by the Assay Act, passed in 1854, which authorised the testing and marking of gold articles of a standard lower than eighteen carat, until that time not legal. The Coventry watchmakers were suffering from the competition of French, Swiss, and American rivals, who could make cases of lower standard, and consequently were rapidly getting all the markets to themselves by underselling. Vast quantities of watch movements were exported to America, there set in cases of lower quality, but equal in appearance, to those which it was legal to make here, and offered for sale as English goods, thus ruining the prospects of the manufacturers at home. The Act legalised three additional standards, viz., fifteen, twelve, and nine carat, providing that these several qualities should be distinctly indicated by marks, so as to protect the purchaser. But the mark itself was everything, and the jewellers, who had been hitherto working in all sorts of standards with no restriction but their own honesty and the sharpness of their customers, gladly seized the opportunity of getting the stamp of genuineness upon their goods. The trade rapidly went up, and in the space of ten years the quantity of gold articles passing through the Midland Assay office rose from 4,000 to 30,000 ounces per annum.

Of late years, a variety of gold jewellery, called *coloured*, has come into fashion. It is of a rich deep yellow, and the surface is slightly frosted; in fact, it is to plain gold what dipped and lacquered brass is to the original article. On account of the gorgeous appearance it presents, it commands great favour in the market, especially as the notion is pretty prevalent that coloured gold must necessarily be pure, or at least of very good quality. Popular opinion is right for once, and, singularly enough, both of these alternatives are true. The quality must be good to begin with, and the surface which meets the eye is perfectly pure. The process of producing what is called *colour* is very simple, and is nearly identical with that of "dead dipping" in brass work. The articles when finished are immersed in a bath of muriatic acid, which eats away the alloy, and leaves a thin crust of genuine gold, very finely granulated in texture, and its natural colour heightened by the disposition of its particles. If the quality were too low, the larger quantity of base metal or alloy, that would be eaten away by the acid, would leave the gold in a honeycombed state, besides destroying the structure of the work; no gold is therefore subjected to this

process that is not at least fifteen-carat standard. A sharp line of division has been created in the trade by the introduction of this method, and the manufacturers of coloured jewellery are considered to follow a distinct branch, higher than that followed by the makers of plain gold work, which may be of any standard, down to none at all.

Plated jewellery comes next in rank, though, as we have intimated, it frequently exceeds in costliness its more pretentious rival. Its peculiarity consists in the fact that the metal is coated or veneered with gold before it is worked up, so that in all the subsequent processes the art of the jeweller is directed to keeping the plated surface outward, and uninjured. The body of the metal is copper, moderately alloyed with brass, or it may be said to be brass of more than average quality. This is cast into bars of convenient size, and the plating is effected in the following way:—A piece about 5in. long is cut off, and the top surface planed, filed, and scraped, to a dead level; it is also pickled, to cleanse it from impurities. A thin plate of gold, also levelled and made perfectly clean, is placed on the top, and the two flat surfaces are bedded together with immense pressure. It was the custom formerly to lay a heavy block of iron, called a "bedder," on the two metals, and strike upon it with sledge-hammers until it was supposed that the contact was complete; but it is usual now to employ a powerful press for the purpose, of the same kind as those used for striking large medals. The machine is not driven in the ordinary way, by two arms, but their place is supplied by a horizontal wheel five or six feet in diameter, of great weight, and loaded also at several points of its circumference with solid iron balls. The upper die, or hammer-block, is raised as far as it will go, and the two plates to be bedded are placed on the smooth anvil below. Impetus is given to the wheel, and it spins round upon the well-oiled screw, gathering momentum as it rotates, until the block comes down with a tremendous thud upon the plates, bedding them at a blow. They are then taken away, and bound tightly together with wire, when the edges are plastered lightly with a solution of borax, and small pieces of "panel" solder are placed here and there, adhering by the moisture. The whole is then placed in a "muffle," or blazing oven, and heated to a dull red, when the solder flashes in between the two plates, and cements them together. Thereafter they can be rolled, drawn, hammered, stamped, spun, or otherwise attenuated to any extent, and the gold will still follow the fortunes of the baser metal, stretching as it stretches, bending as it bends, yielding as it yields to every force impressed upon it, and still preserving faithfully the same proportion of relative thickness, whatever shape it may assume. That thickness is, of course, determined by the quality of the work intended to be made. The gold may be of good honest thickness at last, calculated to stand a good deal of rubbing and hard usage before it is all worn away, or its tenuity may be so extreme that it will scarcely bear touching: but the appearance of the work when finished will be so nearly equal as to deceive any but an expert. Practically, the extent to which the plating can be reduced is limited by the possibility of working it up without injury. One uniform quality is now almost invariably used by jewellers, the fixed price of which, in sheet, is one shilling per ounce; a few years ago the common price was 26s. or 28s., which shows the immense progress that has been effected in the art of making things appear that which they are not. For the present quality, the relative thickness of the two metals would be perhaps in the proportion of 1 to 40.

Gilt jewellery differs from the above in this, that the gilding is done after the article is finished, by the process of electro deposition. It may be that better style is obtainable by this means, the artificer not having before his eyes the fear of injuring the thin gold plate at every step of his operations; and for the same reason, the designer would have more freedom of fancy. The invention of voltaic deposition, it is well known, created a new era for the manufacture of silver-plated wares in this respect; rendering possible the introduction of foliated ornament and the human figure, together with a vast range of intricate design that was beyond the reach of the old method. The superimposed ornamentation, or "mounting," as it was termed, of the old-fashioned plated work, if at all freely designed, was of necessity cast in the solid sterling metal, thereby greatly adding to the cost; and in many points of construction, the maker was restricted by the material he had to deal with. When, however, he found that the new and beautiful discovery which science had made for him would enable him to overlay with the precious metals any fantastic shape he might be able to produce, and that after every detail of its ornamentation was complete, he gave the reins to his fancy, used *all* the resources of the metallurgical arts to obtain form, and succeeded in producing things of beauty, such as the art, with all its ancient glories, had never produced before. It is impossible but that the same causes would affect the manufacture of jewellery, though perhaps in a somewhat less visible degree. The jeweller would be able to use cast or sculptured ornaments upon different parts of his work; he could engrave it deeply, or file it into shape; he could manipulate it at his will; and he could be sure of getting on every part of it at least an even coating of pure gold. But as some alloy enters into the best of metals, so there was an ingredient of evil in this beneficent discovery. There was positively *no* limit to the thinness with which the gold could be overlaid; and so the cupidity of the jeweller was tempted to palm off articles upon the public as honestly gilt, when the merest possible wash existed on the surface. This has brought *gilt* jewellery into disrepute, and given it a rank below that of *plated*, when, in the nature of things, those relative positions should have been reversed.

Compo jewellery is simply the same as the last, with the gilding left out. The makers of this variety aim at getting such a mixture of metals as will look well when finished bright; and some profess to have a secret in obtaining colour; whether well founded or not, the professional buyers are, no doubt, well able to judge. Of this material are made the cheap brooches, earrings, pins, lockets, and other trinkets which are sold by the voluble cheap jack at the country fair, and which, to the eyes of his admiring audience, look equal to the crown jewels at least. A flaming shawl brooch might in this way be retailed for a shilling, which possibly cost the vendor sixpence, and was originally produced for a fraction above a penny! The cheapness of these articles is something marvellous. A few years ago, a trinket called the "book locket" had a great run. It was in the shape of a volume, with hinges and clasp, and the sides or covers of the book marked with an incised ornament of good pattern. Inside were portraits of the Prince and Princess of Wales, fairly executed, and the price, wholesale, was about one halfpenny each! So long as no fraud is practised upon the purchaser, there is no reason why we should deprecate the use of these common and simple articles of personal adornment: the passion is universal; and a fondness for ornament, if bestowed upon objects which have form alone to recommend them, is at least as commendable as the vulgar desire to appear with the wealth of an empire upon the person.

Besides metal, the jeweller's stock in trade consists of precious stones. Of these the name is legion, and the degrees of value almost infinite. The diamond, king of gems, stands at the head of the list, and beneath him are ranged the other colourless transparent stones, such as the chrysolite, the aquamarine, and various other crystals. We have spoken of them as colourless, but the diamond has sometimes a tint, and is valuable therefore. The rule is, that a perfectly white diamond, and one which has a decided uniform tint, are about equal in value, weight for weight; but a diamond partially tinted, or whose tints are clouded and uncertain, is vastly inferior. There is some difference between the Koh-i-noor and a diamond that can be sold for a shilling, yet such is an ordinary price for very small stones of perfect cut. Indeed, some exceedingly small diamonds (used for clusters, or diamond frost) are sold by weight, and have singly no appreciable value. Following the "white and bright" stones, as the trade term goes, are the coloured transparent gems, such as the ruby, the carbuncle, the garnet, the amethyst, the emerald, etc.; and after them the opaque, white and coloured, such as the opal, the sardonyx, the agate, the onyx, the blood-stone, and the turquoise. A great many others might be enumerated; and all are, as it were, heads of families which comprise innumerable varieties. All these are cut or otherwise shaped by the art of the lapidary, some in facets, to enhance the brilliancy, and some, as the turquoise, in bulbous or globular form. No precious substance set by the jeweller in his work is used without shaping by the hand of man, except the two beautiful productions of marine artificers, viz., pearl and coral. Few of the cut stones are either found or worked in England, but are imported, literally by the bushel, from different parts of the Continent. Of

these the cheapest is the sardonyx, and consequently it is the most used. But there are also vast quantities of imitation gems, as closely resembling the originals as the gilt or plated setting resembles pure gold, which, it may easily be conjectured, are used in the same proportion as the false usually bears to the true in other concerns of life besides the manufacture of jewellery. The garnet is the stone most closely and generally imitated, and may be bought, the size of a small bean, regularly cut into facets, for as low as threepence per dozen. France is clever at producing these shams, and a perfect thing called the philosopher's stone, which is not an imitation of anything particular, but has a very beautiful and gem-like appearance, is imported from there in large quantities.

It is estimated that the consumption of gold and silver in the jewellery and cognate trades in Birmingham cannot be less, yearly, than £1,000,000 worth. Stones and their imitations would perhaps absorb a quarter of a million more; so that the trade has not lost its ancient reputation for wealth, acquired in the days when the goldsmiths and jewel-dealers were the bankers of the world. It is by no means an uncommon thing for a large manufacturer to melt down 1,000 ounces of gold bullion at one time; though the rule is, of course, to melt much smaller quantities, down to the fusion of an ounce or two over the kitchen fire. No trade has furnished so many examples of wealthy manufacturers having risen from the ranks; and among the well-appointed factories (some with real architectural pretensions) of the clean and respectable "jewellers' quarter" in Birmingham there are few concerns which could not be pointed at as having had their origin in the "garret." As remarked by Mr. J. S. Wright: "All that is needed for a workman to start with as a master is a peculiarly-shaped bench and a leather apron, one or two pounds' worth of tools (including a blow-pipe); for material, a few sovereigns, and some ounces of copper and zinc. His shop may be the top room of his house, or a small building over the washhouse, at a rent of 2s. or 2s. 6d. per week, and the indispensable gas jet, which the Gas Company will supply on credit. With these appliances, and a skilful hand, he may produce scarf-pins, studs, links, rings, lockets, etc. etc., for all of which he will find a ready market on the Saturday among the numerous 'factors,' whose special business it is to supply the shopkeepers throughout the country."

Having now treated of jewellery *material*, we shall next describe the methods of manufacture.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLV.—BARON BORN, F.R.S.

BY JAMES GRANT.

THIS Bohemian noble, who was one of the most skilful metallurgists of his time, and who, while living, became a martyr to science, was a native of Carlsburg, a royal town and fortress in Transylvania, a place once called Weissenburg, and sometimes Belgrad. His birth occurred some time in 1742. His family was noble, and early in life he was sent to Vienna to study under the Jesuits, who perceiving in the youth more than common abilities, and believing that one day he would prove an honour to their order, prevailed upon him to enter it; but of their society he was only a member, as a novice, for eighteen months.

Leaving Vienna, he went to Prague, where he engaged in the studies of mining and natural history, and the branches connected with them; and in 1770 he was received into the Department of the Mines and Mint at Prague.

From his letters (says Townson, in his "Travels in Hungary") we learn that in the same year he made a tour, and visited the principal mines in Hungary and Transylvania, during which he kept up a correspondence with the celebrated Ferber, who in 1774 published it in his letters. It was during this tour that the baron, then in his thirty-second year, so nearly lost his life, and when he was struck with that disease which embittered the rest of his days, and which a philosophic mind and active disposition alone rendered supportable.

It was at Felso-Banya, a small town of Hungary, in the palatinate of Tathar, where gold mines have been wrought from time immemorial, that he met with his misfortune, as he mentions in his eighteenth letter to Ferber.

There he had descended into a mine, where fire was used as a means for detaching the ore. Of this process he wished to observe the efficacy too soon after the extinction of the fire, and while the mine was full of the noxious and chiefly arsenical vapours raised by the subterranean heat.

"My long silence," he wrote to his friend Ferber, "is in consequence of an unfortunate accident which had nearly cost me my life. I descended the great mine to see the manner of applying the fire, and the effect of the latter on the ore; but the fire was scarcely extinct, and the mine was full of smoke!"

How greatly he suffered in his health from this accident may be inferred from the circumstance that he could hardly bear the motion of his carriage. His friend and correspondent was John James Ferber, the eminent Swedish mineralogist, who, though destined for the profession of medicine under the celebrated mineralogist Von Schwaab, became famous as a metallurgist, and was afterwards Professor of Natural History and Experimental Philosophy in the High School of Mittau, and who, when he closed his life at Berne, in Switzerland, was buried by the side of the illustrious Haller.

Born, after his accident, hastened to Vienna, where he received the appointment of Councillor of Mines at Prague. In 1771 he published a small work of the Jesuit Poda on the various kinds of machinery used in and about mines, and in the following year appeared his "Lythophylacium Borneanum."

The latter was the title of the catalogue of his collection of fossils, which he afterwards disposed of to the Hon. Mr. Greville. By this publication he won the attention of mineralogists, and was drawn into a learned correspondence with the first men of his time. He was now made a member of the Royal Societies of Vienna, of Stockholm, and Padua, and, in 1774, of that of London.

While resident in his native country, Bohemia, he did not apply himself to minerals alone, for the activity of his mind induced him to seek for other opportunities of extending his knowledge and being useful to the world. He took an energetic part in the preparation of a work entitled "Portraits of the Learned Men and Artists of Bohemia and Moravia," and was also concerned in the editorship of the "Acta Literaria Bohemiæ et Moraviæ."

Prague and Vienna were both without a public cabinet for the use of students; and there, at his request, the Government was induced to form one, which he materially assisted by his labours and contributions; and at Prague, in the year 1775, he laid the foundation of a literary society, which issued several volumes under the title of "Memoirs of a Private Society in Bohemia."

The Empress-Queen, Maria Theresa, having now heard his fame, invited him to Vienna in 1776, to arrange and catalogue the Imperial collection; and in 1779 he published his splendid work on conchology, the Empress defraying, from her private purse, the expense of a great many copies; but on her death it was discontinued, her successor, the Emperor Joseph, proving less a patron to science and literature, and caring nothing about the undertaking. Born had, however, the honour of instructing in natural history the Archduchess Maria Anna, who was very partial to that branch of study, and whose museum he arranged and catalogued. In 1779 he was raised to the post of Actual Counsellor of the Court Chamber, in the Department of Mines and Mint, an office which detained him constantly in or about Vienna.

But now the consequences of his accident in the gold mine of Felso-Banya began to recur in the most severe manner; he was attacked with excruciating spasms in the bowels, and these rose to such a degree as to threaten a speedy termination to his life. In this extremity he had recourse largely to opium. A considerable quantity of this was placed near him, with directions that it was to be taken in small doses; but once, being desperate, through the intensity of his pain, he swallowed a large draught, which brought on a lethargy that lasted for twenty-four hours.

When sense returned he was free from pain; but this mysterious disorder now attacked his legs and feet, more particularly the right leg, in which he became lame for the rest of his life. This lameness was sometimes accompanied by pain; and now his feet began by degrees to shrivel and to wither up, so that he was compelled to sit, to lie, or recline upon a sofa;

but he could never again move from room to room without assistance. Notwithstanding this terrible fate, the freedom and activity of his genius induced him to take a deep interest in all the events of his time, and to be active in all those institutions which were slowly being developed for the reformation of mankind. With this object, he became initiated in freemasonry, an order which, under the late Empress-Queen, was obliged to keep itself very secret in Austria, but which Joseph, on ascending the throne, was somewhat inclined to tolerate and even to foster. Hence, the baron ventured to found in the Austrian capital a lodge called the "True Concord," which, though strictly masonic, was nevertheless a society of learned men, whose lodge, after it was opened, became a place of rendezvous for the literati of the metropolis. "No doubt," says Townson, "the obstacles these gentlemen would find to the progress of science and useful knowledge in the church hierarchy, and in the cabals of courtiers, would draw their attention to political subjects; and subjects were really discussed there which the Church had forbidden to be spoken of, and which the Government must have wished not to be thought of. At their meetings dissertations on some subject of history, ethics, or moral philosophy, were read by the members; and commonly something on ancient and modern mysteries and secret societies. These were afterwards published in the 'Diary for Freemasons,' for the use of the initiated, but not for public sale."

As all the learned of Vienna belonged to this remarkable lodge, they gave rise to a periodical work entitled "Physicalische Arbeiten der eintrachtigen Freunde in Wien," which was continued from time to time by Born and his brother masons ("Travels in Hungary," 1797). But what raised him highest in public opinion was his knowledge of mineralogy, and his successful experiments in metallurgy, and principally in the process of amalgamation.

The use of quicksilver in extracting the noble metals from their ores was not a discovery of the Baron's, nor of the century in which he lived; yet he extended so far its application in metallurgy as to form a brilliant epoch in this most important art. After many private experiments, and great expense, he became convinced of the utility of his method, and laid an account of his discovery before the Emperor, who gave orders that a decisive experiment should be made on a large quantity of ore at Schemnitz, the mines of which are the most extensive in Hungary, being some five miles square, and of vast depth, the old tunnel for drawing off the water being 1,100 feet below the surface, and the new being lower still.

To witness this, he invited the most celebrated metallurgists and chemists in Europe, and so thither came Ferber, Elhujer, Charpentier, Trebra, Poda the Jesuit, and others, who universally approved of Born's invention.

This approbation proving so general, he published, by order of the Emperor, his "Treatise on the Process of Amalgamation," with many engravings of the requisite machinery and instruments. If his production brought him fame and emolument, it also won him the ill-will and envy of many of his brother metallurgists; and though great cabals were raised against him and the introduction of his method, the advantages of it were so apparent that the Emperor ordered it to be used in all the Hungarian mines, and as a recompense to Born, gave him, for ten years, the third part of the savings from the process, and 4 per cent. of this third part for the next twenty years.

In 1787 a translation by R. E. Raspe of his "Travels in Transylvania and Hungary" appeared in one volume 8vo in London. Though he suffered very much in the latter part of his life, yet this did not prevent him from continuing his literary pursuits. Hence, in 1790, he published his "Catalogue Raisonnée" of Raab's collection of fossils, which had been formed chiefly by his own donations. This work was printed in two beautiful volumes, and he was in progress with his "Fasti Leopoldini" when a mortal malady seized him. "Notwithstanding the varied advice of his physicians, his disease continued. In such a state quacks find easy access to the sick. Who is not then ready to seize the nostrum of the bold pretender? One of these gave him a decoction, which soon calmed his sufferings, and which he was assured would cure him in a few weeks. He continued the use of this for the last five months of his life; it really diminished his pains, but his friends observed that his cheerfulness, which hitherto had not left him, diminished likewise, and that spasms often attacked his upper limbs. On the 21st of July, 1791, he was seized with spasms and cold; the former subsided on friction, but he lost his speech. On the subsequent days he had different attacks till the 28th, when he found himself better; but he was soon again attacked with spasms, and in these he expired."

His house had ever been open to the travelling literati who visited Vienna, and unprotected genius had ever found in Born a sure patron and firm friend. He carried this so far as to impair his estate, and latterly he became insolvent through usurers and money-lenders, to whom he was compelled to have recourse for money to continue his experiments; hence he left a wife and two daughters in poverty. He was of a middle size and delicate constitution, and had a dark complexion, with black hair, and large black eye-brows. Wit, satire, and a quick comprehension were indicated by his eyes, and all his turns of countenance were lively and pleasing.

He died in his forty-ninth year, and as all his life-long ailments were deducible from the accident which occurred in the mine at Felso-Banya, he was not incorrectly termed "a martyr to science."

OPTICAL INSTRUMENTS.—XXV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

LANTERN CONSTRUCTION (*continued*).

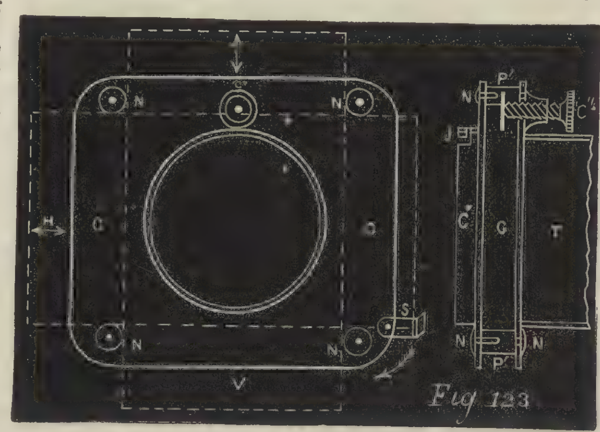
We have now to consider the best method of carrying the slide, and the optical parts by which it is illuminated and magnified. These form one optical system wherein it is necessary that all the elements shall be perfectly centered one to another. In the ordinary lanterns the *front*, comprising the fitting that supports the condenser, the stage, and the conical nozzle that carries the power, is made of tin in one piece, as shown in Fig. 104; but if a lantern is to be used for optical demonstrations as well as for showing views, it is requisite that the stage and power should be separable from the condenser. I have therefore arranged the several parts in the following manner, to meet all the practical requirements of both exhibitor and demonstrator, without sacrificing that rigidity of the optical system which is an essential point in its construction, for securing correct centering of condenser and power by the perfect parallelism of the parts into which they each screw:—

The Condenser Mount.—The advantage of using a pair of symmetrical plano-convex lenses for the condenser is that, by carrying a third lens, should either back or front element be broken or injured, it can readily be replaced, if suitable provision be made for this in the brass mount that supports the pair of lenses. In the ordinary way the front lens is burnished permanently into its cell, while the back lens is either burnished into a screw-ring that is removable to allow of the inner surfaces of the lenses being cleaned, or this lens is kept in position by a cap that screws over it on to the outside of the brass cell. I prefer making the cell in the following manner, as it provides, as far as possible, against the lecturer being placed *hors de combat*, and to facilitate repairs should the operator be located in a foreign or out-of-the-way place. The cell, C (Fig. 121), is made of brass tube a size larger than the diameter of the lenses; one end is turned up with a bezel, B, on to which the flat face of either lens is dropped. Over the lens, close inside the cell, a brass ring, R, fits; on to the edge of this ring the back lens is placed curved face downwards; and over all the cap-ring S is screwed, so as to keep all firmly in position. Three or four ⅛-inch air-holes are cut through the outer and inner tubes of the cell, to allow of moisture escaping freely. The condenser mount is turned quite smooth on the outside to allow of its fitting smoothly into

The Flange.—This consists of a tube a size larger than the condenser cell, soldered into a circular or square plate F, which is attached by three counter-sunk screws to the body of the lantern. The inner half of the tube fits a hole cut in the body of the lantern; the outer half is polished and fitted with an upright pin, P, that forms the stop of the bayonet-joint on the stage.

The Stage is usually open only at the sides, being closed above and below, and the frame that carries the slide is held in place by a spring-plate, as shown in Fig. 122 at A and B. All exhibitors must have experienced the inconvenience attendant on the employment of a spring-plate, when an extra thick frame, such

as "the rolling waves effect," has to be pushed into the old-fashioned stage, a matter only to be accomplished by much wriggling of the frame, to overcome the sticking when the stiff springs are jammed home. Again, there are many excellent "effects" which could be introduced to the general public, such as balloon ascents, ascending fairies and descending demons, etc., if the slides could be worked vertically in the same manner as panoramic slides are moved horizontally, but which the solid top and floor of the stage as thus made prevents. To obviate such shortcoming I employ two stout brass plates, pierced with central openings, and frame them together with four brass pillars, P′, and eight spherical-headed screws, N (Figs. 121 and 123), to allow of frames being inserted horizontally in the usual way, as shown at H (Fig. 123), or vertically, as at V; and dispense with the spring-plate altogether, to allow of a standard frame being simply pushed in without impediment, so as to rest upon the lower pillars, in which position it will stand upright, or can be prevented from falling forward by means of a quick-action screw guarded by a button, which works through the front stage-plate, as shown at C″ (Figs. 121, 123). This clamp-screw is very convenient, as it can be turned back rapidly to allow of the insertion of a frame of any thickness the opening between the plates of the stage will admit of; or it will firmly clamp any mechanical frame, and leave both hands of the exhibitor free to work it, thus providing great freedom of action for any effect that can be devised. To ensure the slide being centered with the optical system, a small brass arm, bent out at a right angle, works stiffly on a pivot screwed in the stage-plate, on the side opposite to that on which the frame is inserted, as shown at S (Fig. 123), so that it can be turned up to stop the passage of any frame of a standard size, when central with the axis of the optical system, or down out of the way, as indicated by the arrow, if the frame is panoramic or of unusual length. To the back of the stage-plate is attached a "counter-flange ring," C′ (Fig. 121), which is one size larger than the outside of the tube of the flange F, whereon it fits, and is fixed in position by a bayonet-joint, J, to ensure the sides of the stage-plate standing truly parallel with the sides of the lantern body. To the front stage-plate is attached the large tube T, within which slides another tube T′, not only for the purpose of providing a certain amount of adjustment when lenses of different focal length are employed, but to provide for the quick interchange of certain accessory apparatus and demonstrating appliances. The end of the inner tube is fitted with a female screw-ring, A, into which the *jacket*, J, of the power screws, or the "lengthening tube," L, when a lens of long focus is to be employed.



The *standard frame*, for pictures 3 inches in diameter, is 7 inches long by $4\frac{1}{2}$ wide, and $\frac{3}{8}$-inch thick. It should be made of mahogany, not cedar, as that gives off a resinous vapour (when the weather is hot or the frames have been warmed by use in the lantern) which condenses on the cold glass slides in hard drops that are very troublesome to get off. According to the old style the pictures were painted on glass discs, which were dropped into counter-sunk cells turned in solid blocks of wood, and kept in place by a coil of spring wire. This plan is very objectionable, as the design is apt to turn round in its cell, and of course appears askew on the screen. The modern method, introduced with the photographic system of producing slides, ensures the design being central and standing true on the screen, as they are in the first instance photographed in accurate adjustment on glasses $3\frac{1}{2}$ inches square. Such designs are protected by double glasses between which an ornamental paper mount is inserted to "stop out" all parts not included within the 3-inch disc, the edges of the two squares of glass being bound together by strips of dark purple paper. Such slides are fitted into grooved frames of the size given above, three sides of which are tongued and glued together, the fourth side being left free to allow of the insertion of the 3-inch square slides. When in place the whole forms a solid block with the design perfectly centered. I run a bead along one long edge of the frame, so that the exhibitor may know that when the bead is uppermost and towards his breast, then *the slide* is in a doubly-reversed position in the frame, and in the right position for being inserted in the stage, to secure the image on the screen appearing as it should do, especially if there should be any inscription on it. The paper *stop-mount* should be printed in black, with a white design from a wood-cut around a 3-inch circle, within which a square, measuring 3 inches across its diagonal, is laid down. A design should provide for two scrolls whereon could be inscribed *the nature of the series*, such as "Science," "Geography," "History," "Hogarth," etc.; *the name of the subject*, such as "Solar Spectrum," "Map of the World," "Falls of Niagara," "Finis," and two shields *for the number of the series*, and the monogram or trade-mark of the publisher. Instead of a paper stop-mount, such a design may be transferred to the covering glass in black and gold, which pre-

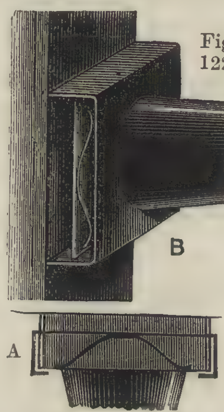
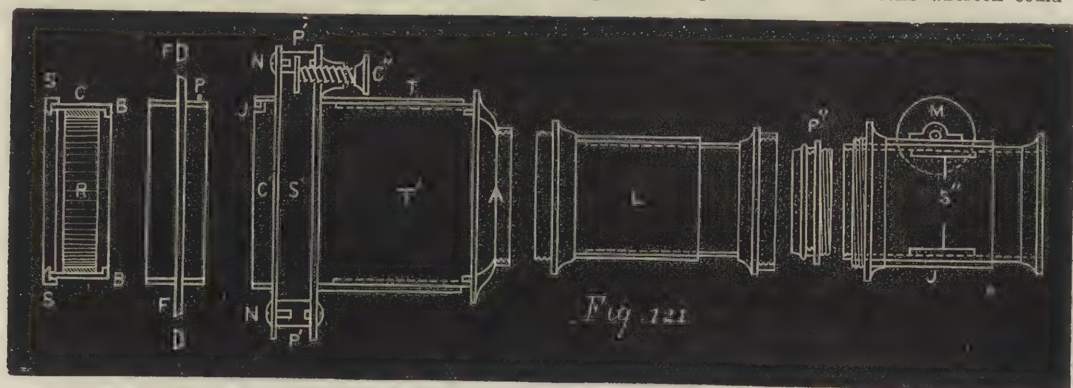


Fig. 122.



sents a remarkably handsome appearance to the slide, at but little cost to the producer. The stop-mount, whether made of paper or printed on glass, must for some subjects be of square design 3 inches at the sides.

The *lengthening tube* is simply two pieces of tube, fitting one inside the other, after the manner of a telescope, as shown in L (Fig. 121), one piece being furnished with a male screw that turns into the front tube, T′, and the other with a female screw that receives the jacket, J, of the power. This is only used when a lens of long focus is required. If the focal length is very great, it is better to give support to the front by placing a wooden crutch under this tube.

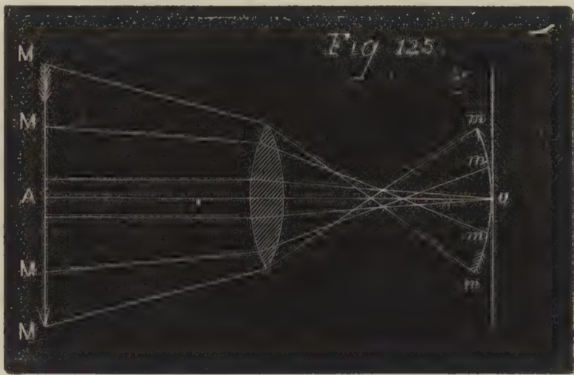


Fig. 125.

The *power*, or "objective," P″ (Fig. 121), is the magnifying element of the optical system, and should be so constructed as to be free from spherical and chromatic aberrations, that the picture may appear clearly defined over the entire surface of the disc on the screen.

The power used in the cheapest forms of lanterns is the double-convex lens, A (Fig. 124), or spectacle glass, of $2\frac{1}{2}$ or 3 inches focal length; in those of somewhat better construction a plano-convex of $3\frac{1}{2}$ inches focus is employed, as at B (Fig. 124), with a stop before it to diminish the amount of spherical aberration; while in the best of the ordinary or old-fashioned make, a pair of lenses are used for this purpose. Duboscq of Paris adopts a pair of double-convex lenses, as at C (Fig. 124). At the Polytechnic Institution, two plano-convex lenses with their curved faces towards the slide are employed (S, Fig. 124, represents the slide, that the proper position for all the lenses may be indicated), and in phantasmagoria lanterns either a pair of meniscus, as at E, or a plano-convex and a meniscus, as at F (Fig. 124). Such combinations are well suited to meet the requirements of flatness of field and good illumination with economic production. Nevertheless, they possess three defects which are of consequence in instruments of the highest class—viz., spherical aberration, chromatic aberration, and refractive aberration.

Spherical aberration is due to unequal refraction at different portions of a lens, the incident marginal rays, M, being more refracted than those nearest the axial ray, A; consequently they are collected at different foci, *m*, instead of on one plane, as shown in Fig. 125; the result being a more or less confused image of the object on the screen, according to the form and position of the lens in relation to the object (or slide). The greater the convexity of the lens, or the greater the inequality of the curves on its two faces in relation to the direction of the incident rays, the greater will be the amount of spherical aberration.

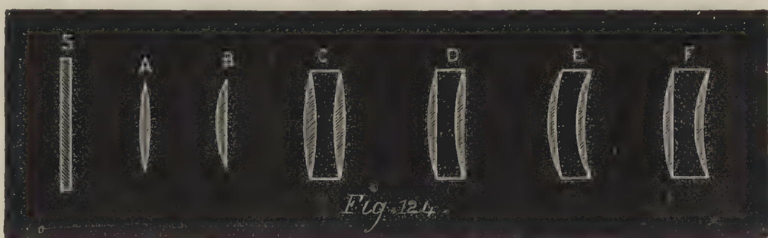


Fig. 124.

It is, therefore, less in a lens of periscopic form, which renders the marginal rays longer than the axial rays, when the concave side is presented to the object to be reproduced as a reduced image and in reversed position for an enlarged image. Spherical aberration may be reduced, but never completely destroyed, by the proper use of a diaphragm or stop, by which we cut off the marginal rays to a greater or less extent, and in proportion as we decrease the size of the aperture of the stop, we secure a flatter field, and consequently increased definition or sharpness of the image; but as this method involves a considerable reduction in the amount of light transmitted, it is practically inapplicable to the case of magic-lantern objectives, except to an exceedingly limited extent. The spherical aberration of a lens may, however, be completely destroyed by a second lens of a contrary character; thus, convergent lenses must be corrected by divergent lenses of suitable curvature, and *vice versâ*. A convergent and a divergent lens may be cemented together, or they may be separated by a greater or less distance, or they may be of different diameters. Both lenses may be made of the same glass; but as a rule, the lens of a concave character is made of a different quality, as it also serves to correct the chromatic aberration. Such combinations act as a single convergent lens free from spherical aberration, and are termed *aplanatic*. It is impossible to construct a single convergent lens, or to associate two or more of them on a common axis, in such a way as to destroy spherical aberration; and though the contrary is asserted in many works on physics, we must recollect that this belief originated with the error in Sir John Herschel's memoir in the *Philosophical Transactions* published many years ago, and which, as previously stated, he only detected and corrected in 1861.

As the correction of the chromatic aberration is of greater importance than the spherical aberration, it frequently happens that the concave lens corrects too much or too little of the spherical aberration of the convergent lens: in the former case the combination is said to possess spherical aberration of a *negative* character, and the latter *positive*. A common form of lens corrected for spherical aberration is the achromatic plano-convex lens. If we take a combination of this character, of about 5 inches focus, as the power, we shall find if we place the flat side next to the slide that the image produced on the screen will be intensely sharp in the centre, but that the definition falls off rapidly towards the edges of the disc. If, on the other hand, the curved side of the lens be turned towards the slide, the image will not appear absolutely sharp in any one place, but there will be a uniformity of character in the definition, that points this out as the best position, even though the result is not all that could be desired. The shortcomings of a single achromatic lens may be overcome by painting or photographing the design on a slightly spherical glass, of such a radius of curvature that it will balance the amount of uncorrected spherical aberration of the lens. This method was adopted by the late Mr. James Holland, and also by Andrew Ross. These gentlemen, in order to be able to surmount the difficulties which they found were presented by the gas microscope, mounted the objects they wished to examine on small watch-glasses. The spherical aberration may also be destroyed by receiving the image on a concave screen, the curvature of which must correspond to the curvature of field resulting from the optical defect of the instrument. Such a method of destroying the spherical aberration is the least practical of any that have ever been suggested, though it might be employed in connection with the gas microscope where a large screen is not required for class demonstrations.

The usual method adopted for extending the area of good definition, is that of employing a second achromatic lens. Where, however, we are dealing with weak lights—such, for example, as the Argand burner—we can ill afford to lose the amount of light absorbed and reflected from the cemented surfaces of a second achromatic lens; hence, if we wish to show photographic slides, we are forced to rest content with a single achromatic combination, so it is of importance to adopt a power of the best possible form and of as short a focus as is compatible with good performance.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVI.—DISCOVERIES OF SIR HUMPHREY DAVY.

NEARLY a century ago there was born at Penzance, in Cornwall, a boy whose genius was distinguished by very remarkable precocity, who before he was two years old could speak fluently, and who could repeat a great part of the "Pilgrim's Progress" before he could well read it. He had an extraordinarily strong perception; for he would, at the age of five years, turn over the pages of a book as rapidly as if he were merely engaged in counting the leaves or in hunting after pictures, and yet, on being questioned, he could generally give a very satisfactory account of the contents; and the same facility was retained by him through life. But he was more remarkable out of school than for any great advance in learning. He excelled in story-telling, partly from books, particularly from old people such as had a rich store of traditions and marvels. Such was Humphry Davy, who, says his brother, was at this time a clever boy, but not a prodigy. He was regular in his school duties, but scarcely developed any extraordinary abilities. At the age of fifteen, his school education was considered completed, and his self-education, to which he owed almost everything, was about to commence.

But before entering in any way on the discoveries and inventions which Davy made and produced in the course of his too brief but useful career, we may be permitted to state what is known of his family. Davy himself was of humble origin, for his father was occupied as a carver in wood; but notwithstanding this, his connections were chiefly to be found among the yeoman class, of whom more exist and have existed for years in the western counties than in any other part of England, while his ancestors were small landowners, having long possessed an estate of limited extent at Varfell, in the parish of Lugdvan. He was sent, with his brother, John Davy, who afterwards acquired eminence as a chemist, geologist, and physiologist, and who wrote a biography of the subject of our sketch, to a school in Penzance, kept by Dr. Cardew, where, as it has been said—although he did as fairly as other boys of the same age—he gave no particular indication of the innate talent for which he was afterwards so remarkably distinguished, nor signs of his aptitude for chemistry and other kindred sciences in which he subsequently acquired such a world-wide reputation. His imagination in his earliest years was vivid and fertile, and many pieces of poetry are extant which were written by him when a boy at school.

On leaving school he settled to study. Early in 1795 he was apprenticed to a surgeon and apothecary in Penzance; and about this time he commenced his note-books, the earliest of which contains a plan of study, and hints, and essays, in which, "with all the daring confidence of youth, he enters upon the most difficult problems in metaphysics and theology, and employing a syllogistic method of reasoning (which, as he observes in his 'Consolations in Travel,' young men commonly follow in entering upon such inquiries), he arrives, as might be expected, at a conclusion contrary to the good feelings and common sense of mankind."

Next year Davy entered on the study of mathematics, and finished the elementary course; he was very systematic. But his favourite pursuit was metaphysics, and his rough notes show an acquaintance with the writings of Locke, Hartley, Bishop Berkeley, Hume, Helvetius, Condorcet, and Reid and other Scotch metaphysicians. These studies he soon associated with physiology. In 1797 he began in earnest natural philosophy; and in his nineteenth year he commenced the study of chemistry, with Lavoisier's "Elements" and Nicholson's "Dictionary." His experimental apparatus consisted of phials, wine-glasses and tea-cups, tobacco-pipes, and earthen crucibles; and his materials chiefly the mineral acids and the alkalies. He began to experiment in his bedroom, and sometimes he went down to the kitchen-fire with his crucibles. In four months he was in correspondence with Dr. Beddoes, relative to his researches on heat and light, and a new hypothesis on their nature, to which the experienced Dr. Beddoes became a convert. The result was Davy's first publication, "Essays on Heat and Light," in 1799, which had been in part written a few months before he had commenced the study of chemistry. "Such," says his brother Dr. Davy, "was the commencement of Humphry Davy's career of original research, which in a few years, by a succession of discoveries, accomplished more in relation to change of theory and extension of science than, in the most ardent and ambitious moments of youth, he could either have hoped or imagined possible." Most of the peculiar views developed by him were speedily abandoned; his brother admits that many of the speculations were wild and visionary, and adds what will readily be admitted, that "the wildest of them are most natural to a young mind just entering on the twilight of physical science, gifted with high power and a vivid imagination."

Davy, when nineteen summers old, among other things, concluded that oxygen, as it exists in the atmosphere, is a compound of real oxygen and a matter of light; that when a taper burns, this light is set free, while the wax unites with the actual oxygenous principle of oxygen, and melts "into thin air;" that when a man inspires, this "phosoxygen" (such was the name he put upon the ordinary oxygen of the atmosphere) is absorbed by the blood, carried to the brain, and there decomposed into true oxygen and light; and that the light thus liberated within the most intimate recesses of "the golden bowl," from which the stream of higher life appeared to permeate the body, is the nervous energy, and the proximate cause of sensation, perception, and emotion. In sad and sober earnest, the enthusiast was then a materialist; and this dazzling vision, which sanctified the divinity to his kindled imagination, was a compromise between his impersonal piety and the eminently practical but brilliant science by which he was taken captive. This eloquent episode appears in the *North British Review*, No. 3, as "Davy's Early Dream."

One of Davy's constant associates was Mr. John Harvey, a druggist at Penzance, who supplied him with chemicals. They frequently experimented together; and one severe winter's day, after a discussion on the nature of heat, the young philosophers were induced to go to Larigan River, when Davy succeeded in developing heat by *rubbing two pieces of ice together*, so as to melt each other. [Could we, by mechanical pressure, force water into a solid state, an immense quantity of heat would be set free.] This experiment Davy repeated with much *éclat*, many years after, in the zenith of his celebrity, at the Royal Institution. The pieces of ice for this experiment are fastened to the ends of two sticks, and rubbed together in air below the temperature of 32°; this Davy readily accomplished on the day of severe cold at Larigan River; but when the experiment was repeated at the Royal Institution, it was in the vacuum of an air-pump, when the temperature of the apparatus, and of the surrounding air, was below 32°. It was remarked that when the surface of the rubbing pieces was rough, only half as much heat was evolved as when it was smooth. When the pressure of the rubbing pieces was increased four times, the proportion of heat evolved was increased sevenfold.

Davy had already become the friend of Mr. Gregory Watt (son of the celebrated James Watt), and with him visited the most remarkable mines near Penzance, collecting specimens of rocks and minerals. And here, working the Wherry Mine, situated beneath the sands, and its shaft in the sea, young Davy saw a steam-engine at work, this being one of the earliest of Watt's steam-engines that had been introduced into Cornwall.

Meanwhile Davy's progress in medicine was such, that in the fourth year of his studies he was considered by Dr. Beddoes competent to take charge of the patients belonging to the Pneumatic Institution at Clifton, thus entering on his public career before he was twenty years old. He now applied himself with great zeal to complete his experiments and essays on light and heat; and, above all, on the effects of the gases in respiration. Of these, nitrous oxide was the first experimented on; and Davy's discovery of its wonderful agency was the origin of the researches which established his character as a chemical philosopher. In April, 1799, "he first breathed nitrous oxide: ten months of incessant labour were employed in making them; three years in detailing them. The author was under twenty years of age, pupil to a surgeon and apothecary in the most remote town of Cornwall, with little access to philosophical books, and none at all to philosophical men." (Davy's "Researches"). So intense was his application, and so little his regard for health or even life, that he nearly lost it from the breathing of the carburetted hydrogen, and was compelled for a time to leave the laboratory.

MINING AND QUARRYING.—XXXVI.

BY GEORGE GLADSTONE, F.C.S.

SALT.

COMMON SALT (CHLORIDE OF SODIUM); CHEMICAL FORMULA, NaCl.

DEFINITION—ABUNDANCE—GEOLOGICAL DISTRIBUTION—GEOGRAPHICAL—UNITED KINGDOM—AUSTRIA—SPAIN—GERMANY—RUSSIA—MEDITERRANEAN—AMERICA—ASIA—DEAD SEA—ELTON LAKE—AFRICA.

THERE are few articles more indispensable to the well-being of man than salt, and through the wise ordering of Providence there is scarcely one which is so widely diffused in nature. It is familiarly known as an article of food, being almost the only mineral substance which is eaten as such, and used alike by savage and civilised nations; but it is also very largely employed as a preservative of animal substances from decay, in the manufacture of other chemical products, and in a variety of minor ways. It occurs in nature both in the solid state and in solution; in the former case, as rock salt or saline incrustations; and in the latter, as salt springs and lakes more or less saturated, and in the waters of the sea.

The distribution of salt, geologically considered, is scarcely less extended in range than it is in geographical area. The principal accumulations of rock salt in England are in the Permian and Triassic deposits, but if we pass to the United States of America we shall find that the rocks which are attributed to the Salina period, on account of their general impregnation with salt, are of an antiquity equivalent to our upper Silurian. If, on the contrary, we pass eastward to the greatest deposits of rock salt in Europe, and, so far as is at present known, the greatest in the whole world—those extending immediately to the north of the Carpathian Mountains—we shall find that they belong to the Tertiary epoch. Further, we shall presently see that the process of deposition is still going on in some of the inland seas and lakes, especially those of Central Asia; and the same mineral is not unfrequently one of the products of volcanic eruptions. Its occurrence, therefore, extends in geologic time from the older Palæozoic to the present period, and is due to the most opposite of agencies—fire and water.

Our own country occupies the foremost place in this industry. The United Kingdom not only furnishes almost the whole of the salt which is consumed within her borders, but also exports large quantities to India, the United States, and other countries. The annual produce is about one million and a half tons. By far the greater portion is raised in two counties—Cheshire and Worcestershire. About two hundred years ago, while boring in search for coal at Northwich in the former county, a bed of rock salt was discovered instead, at a depth of about 100 feet from the surface, which proved to be 90 feet thick. This was underlaid by a stratum of indurated clay, and for more than a hundred years the proprietors of the mines were satisfied to work this bed without exploring further. Subsequently, on boring through the underlying clay to the depth of a little over thirty feet, a second bed of rock salt was found, which proved to be of the same thickness as the upper one; the lowest portion of the lower bed was, moreover, much freer from earthy admixture than the rest, the purest stratum being from twelve to fifteen feet thick. These two deposits occupy a depression of about a square mile in area, immediately to the north of the town, and have been the great source of supply from the time of their first discovery to the present day. The salt is prepared for use at Northwich, and then sent by craft to Liverpool for shipment. At Lawton, in the same neighbourhood, three beds of rock salt were found about a hundred years ago, the thickness of the two upper ones being four and twelve feet respectively, while that of the lowest is upwards of 70 feet. It was the discovery of this third bed, and the circumstance that the lower portion of it is the purest, which led the proprietors of the Northwich mines to carry their explorations down into the second bed.

Wherever any quantity of rock salt occurs below the surface of the earth, it follows almost as a matter of necessity that there will be brine springs more or less saturated, because the water in percolating through the saliferous strata will dissolve out the salt. In most places, therefore, where rock salt is procured, the water pumped up is also preserved for the sake of that which is held in solution; while in many cases, where the layers are very thin and much mixed with earthy matter, the attention of the miner is exclusively devoted to the brine.

In Worcestershire, and particularly in the neighbourhood of Droitwich and Stoke, brine springs are very numerous, and large quantities of salt are made. At the former they are met with at a depth of 175 feet, but at the latter the borings have to be carried down to double that distance. They are usually lined with iron pipe or wooden casings, in order to keep out any fresh-water springs which may be encountered in the upper strata. The saliferous deposit extends also into Staffordshire, at Shirleywich, Weston, and other places; and in Lancashire powerful brine springs occur at Barton.

About ten years ago a bed of rock salt was struck in boring for water at Middlesbro'-on-Tees, at the great depth of 1,206 feet, which was found to be 99 feet in thickness, and underlain by a sort of conglomerate consisting of salt and limestone mixed together. The product of the brine which is pumped up from this depth, after evaporation, gives 96·6 per cent. of salt, the rest being principally gypsum. The strata bored through belong to the same geologic period as those of Cheshire.

In Ireland a considerable deposit of rock salt, in the neighbourhood of Carrickfergus, is worked to the extent of some 25,000 tons annually; but there is no deposit of any consequence in Scotland.

With such sources of supply as these, the unlimited one which encircles the British Isles is almost neglected, especially as the small per-centage in sea-water will not admit of its being evaporated down by artificial heat, and the climate is scarcely suitable for doing it otherwise. Nevertheless, some quantity of sea salt is manufactured in Hampshire, on the Tyne, and along the shores of the Solway Firth.

Turning to the continent of Europe, the most remarkable deposits of salt which we have to notice are those in the Empire of Austria. The province of Galicia can boast of the most extensive one known. It extends over an area of some 10,000 square miles, and is principally worked at Wieliczka and Bochnia, two considerable towns twenty-two miles apart, almost the entire population of which is engaged in the salt trade. The underground workings at the former mine are over thirty miles in length, constantly opening out into large halls, the dimensions of which sometimes attain to about 150 feet in length by 80 in breadth, and 100 in height, being by far the largest artificial excavations in the whole world. They are carried to a depth of 860 feet, the greater part of it through solid salt, the beds of the mineral being thicker than the earthy partings. The annual product of this mine is about 48,000 tons. Rock salt is common in many parts of the Eastern Alps and of the Carpathians, and is worked largely in the district of Marmoros, in Hungary, which yields annually about 28,000 tons; and at Maros-Ujvar, Vizakna, and Parajd, in the province of Transylvania, whence 68,000 tons are obtained yearly. In the region of the Alps the salt is more intermixed with earthy matter, and occurs in smaller masses, so that little rock salt is worked; but very large establishments exist for pumping up the brine and evaporating it down. The principal centres of these operations are Ischl, Hallstadt, Hallein, Aussee, Hall, and Soovar. About 100,000 tons are manufactured annually at these works. On the coast of the Adriatic nearly 30,000 tons are made every year by evaporating the sea-water, which is there somewhat richer in salt than the water of the Atlantic.

Spain possesses a remarkable deposit at Cardona, where a solid mass completely fills up the head of the valley, and is quarried in an open working, the excavations having left exposed a lofty cliff composed almost entirely of rock salt. The works, however, at Añana, in the Basque provinces, are the largest in the country.

Salt springs occur over a very wide area in Germany—viz., at Reichenhall, in Bavaria; at Friedrichshall, Sulz, and other places in Würtemberg; at Halle, Stassfurth, Schönebeck, and Artern in Prussia, etc. At these places brines are obtained which contain from 10 to 26 per cent. of chloride of sodium. The higher figure is almost equal to that of a saturated solution, the maximum quantity found in the mother liquors of brines being 28·8 per cent. In many other places, such as Sulza, Kösen, Dürrenberg, Münster am Stein, etc., there are springs containing smaller per-centages of salt, which are utilised in a way to be described subsequently.

The Putrid Sea, and the lakes or lagoons which immediately border it and the Sea of Azov, are highly impregnated with salts, of which the greater portion is the chloride of sodium. Some of

the latter have as much as 18 per cent. of the common salt, together with about 8 per cent. of the sulphate and chloride of magnesium. The Putrid Sea contains rather more than 14 and 3 per cent. of the sodium and magnesium salts respectively.

On the Bessarabian shores of the Black Sea considerable quantities of salt are annually collected, and the limans or lakes from which the supplies are derived furnish a very instructive illustration of how deposits of rock salt may accumulate. From the mouth of the Danube as far as the Dnieper all the rivers, before terminating in the sea, expand into lakes of greater or less extent, which are separated from the sea by natural dams. The water flows into the sea through an opening in the dam, while, on the other hand, during storms, sea-water flows into these limans. In the water of the extensive limans which are formed by the larger rivers, as the Dnieper, Dniester, etc. etc., which receive a large volume of fresh water, the proportion of salt is so small as not to be perceptible to the taste. The three Bessarabian limans, however, situated to the south-west of Odessa, become partially dry every summer, and deposit their salt in crystals, which, in the neighbourhood of the shore, are of small size, and form beds of only ½ to 1 inch thick; but in the middle of these limans the crystals are larger, and often form beds 1 foot in thickness. Nearly 100,000 tons of salt have been collected from these limans in the course of a year. This is the more surprising, as the waters of the Black Sea itself only contain 1·4 per cent. of chloride of sodium.

Along the coast-line of Portugal a considerable amount of sea salt is collected, and on the shores of the Mediterranean the evaporation of the sea-water for the same purpose is carried on very extensively, especially along the south coast of France and in the islands of Sardinia, Sicily, and Cyprus.

In America the most remarkable region is the Valley of Utah, or the Great Salt Lake. The lake itself is about 300 miles in circumference, and the waters are intensely saline; besides which the shores all round, for some considerable distance, are encrusted with this mineral. In the southern hemisphere there are salt plains in Peru and other parts, where rain scarcely ever falls; some of them are high up the Andes, that of the Pampa de Sal being nearly 15,000 feet above the sea-level. The salt in many places permeates the soil, and in others forms layers 8 or 10 inches thick. It is associated there with nitrate of soda and biborate of lime. The salt lakes which are common in the plains of Patagonia contain almost pure chloride of sodium.

In Asia there are several localities where remarkable deposits of salt occur. At Lahore, and in Affghanistan, the rock salt attains a great thickness, as much, in some cases, as 100 feet. In Persia there are mines wrought, which, although the layers are only 6 to 18 inches thick, yield salt of great purity, so that pieces of 2 inches in thickness can be procured from them which shall be perfectly transparent. The island of Ormuz, in the Persian Gulf, consists principally of rock salt; and many of the almost rainless deserts in that country are covered with a saline efflorescence which glistens with dazzling brightness under the burning unclouded sun.

Central Asia, moreover, possesses many inland seas and lakes the water of which is intensely salt, and is doubtless precipitating solid salt, as, in consequence of their having no outlet, the quantity of saline matter must be constantly increasing. The largest of these is the Caspian, but the water of this is not so salt as that of some of the smaller lakes. The Sea of Aral, the Dead Sea, Lakes Van, Ooroomiah, and Balkasch, are all salt; that of Ooroomiah the most highly impregnated of all, as it lies in a region where all the soil is more or less salt, and some of the small streams which feed it pass through considerable beds of solid rock salt. One of these occurs in Red Mountain near Tabreez, from which a stream runs into the lake, the water of which is too salt for comfortable use; and another of these is at Khoy, about ten miles north of Lake Ooroomiah. The rock salt is remarkable for its extreme purity, as limpid as rock crystal, and without even a trace of either the sulphate of lime or of magnesia. The lake is 82 miles long by 24 broad, and the water contains 19 per cent. of chloride of sodium.

The Dead Sea is not so remarkable for the quantity of this salt as for the general total, those of magnesium and calcium being usually about the double of that of sodium. The relative proportions, however, vary very greatly, according to the season of the year, so that the recorded analyses of the waters are widely discordant; but this very circumstance is a matter of no little interest, as illustrating a chemical fact which may have a good deal to do with the formation of other deposits of rock salt. The Dead Sea lies more than 1,300 feet below the level of the ocean, and whether it was ever connected with it or not—a point upon which physical geographers are far from being agreed—it is certain that whatever salts are washed down by the Jordan and other rivers must now remain there, the inflowing water being carried off by evaporation alone. Now the Jordan, which pours into it the greatest quantity of water, contains twelve times as much chloride of sodium as of chloride of magnesium in solution; and at Kashum Usdum, on the south-west shore of the lake, is a ridge of rock salt 100 to 150 feet in height and five miles in length, the water draining from which will also bring down large quantities of chloride of sodium. How, then, it will be asked, does it happen that the quantity of magnesium is so much in excess of that of sodium? The explanation is this: that the solubility of chloride of sodium in water diminishes, the greater the amount of chloride of magnesium therein dissolved. The more, therefore, the latter becomes concentrated by evaporation, the more rapidly is the chloride of sodium deposited. As the surface water of the Dead Sea is practically a saturated solution, containing in the dry season more than 26 per cent. of saline constituents, the natural inference is that a deposition of common salt is taking place at the bottom, more or less rapidly according to the season of the year.

There is another salt lake in the depressed region of Central Asia, which is of considerable interest. The surface of the Elton lake is somewhat below the level of the ocean, and the streams which supply it with water pass through districts where the soil is highly impregnated with salts. The lake is very shallow, and therefore presents a large surface in proportion to the quantity of water it contains. Being situated in a climate where the changes of temperature between winter and summer are very great, the waters of the lake are likewise subject to great changes in their chemical composition. They are, in fact, a concentrated mother-liquor from which, for a long period, common salt has been deposited, and still continues to be deposited during the summer months, the water brought into the lake being at this season less than that which is removed by evaporation. In general, a deposit of common salt takes place in this lake every summer. From 1747 to 1851 there was only one year, 1776, in which such deposition did not take place. The summer of that year was, however, very rainy and cold. At the distance of two versts from the margin of the lake a well was dug. The uppermost strata of salt were two-thirds of an inch to 2½ inches thick. After forty-six such strata had been penetrated, their thickness increased to about 8 or 9 inches, and at length, after penetrating 100 strata, a very compact bed of salt was reached. Analyses have been made of the waters of the lake at different seasons, showing great variations in the relative proportions of the chlorides of sodium and magnesium.

Per-centage Proportions.	By Göbel, in April.	By Erdmann, in August.	By H. Rose, in October.
Chloride of sodium . .	13·124	7·451	3·83
Chloride of magnesium .	10·542	16·280	19·75
	23·666	23·731	23·58

At first sight the great difference in the three analyses may appear somewhat surprising. The sums of the two salts given are, however, nearly equal in all three; as the one of these two salts decreases, the other increases, and *vice versâ*. The water analysed by Göbel was obtained in spring, when the influx of water was very great, and the evaporation very slight; whereas Erdmann's specimen was obtained in summer, Rose's in autumn. In proportion, therefore, as the amount of water removed by evaporation becomes greater, the chloride of sodium diminishes—a deposition of it taking place—while the chloride of magnesium increases. A time will come when the Elton lake will have become quite saturated with the latter; the deposition of common salt will then increase, for a saturated solution of chloride of magnesium can hold only 1 per cent. at most of common salt in solution. Circumstances will then be still more favourable for the preparation of salt from the water of

the Elton lake, which even now yields about two-thirds of the entire amount of this substance consumed in Russia; it will, however, become less pure, containing more chloride of magnesium.

Africa also possesses salt plains, and this mineral constitutes one of the most important articles of commerce in the deserts of the interior, whole caravans being laden with this article alone. One of these plains lies within fifty miles of Annesley Bay, on the Red Sea, where at least 750,000 pounds of salt are produced weekly; the pieces of salt (which usually weigh something over one pound each) serve as a circulating medium in Abyssinia until required for consumption.

THE LATHE.—XV.

By Henry Northcott.

SELF-ACTING TURNING AND SCREW-CUTTING.

Ordinary plain traverse turning may be performed in any self-acting lathe, whether the traverse of the tool is derived from a leading screw, or from a rack and pinion; but screws can only be properly cut in lathes furnished with a correctly-made leading screw and set of change-wheels. Screw-cutting is always a secondary operation, as the blank shaft out of which the screw-groove is to be cut must first of all be carefully turned to the proper size with the ordinary traverse. To turn up a plain cylindrical shaft or bar it is necessary first of all to correctly centre the rough iron, and to straighten it. The centre mark is in the first instance knocked into the ends by a hard steel centre-punch, ground to about the same angle as the lathe-centre. If the shaft be longer than the required finished shaft by much more than is necessary for facing up the ends, it is put between the lathe-centres upon the preliminary centre-marks or indents made with the punch, and before further trouble is taken in centering or in straightening it, the ends are roughly turned off so as to leave the bar only just long enough to allow the ends to be finished up when the shaft is properly turned. If a number of such shafts have to be turned, they are all served in this way before any further step is taken in turning any one of them. Frequently the whole operation of centering, cutting off the ends, and straightening necessary to prepare work for the turner, is prepared in a separate rough lathe, and by another workman, so that when the shafts reach the self-acting lathe they are quite ready for turning up. This system, however, can only be carried out in large engineering works where the quantity of turned work is sufficient to render a subdivision of labour advantageous. Ordinarily the turner has to prepare his own work for turning, and the cutting off to the right length will be his first labour. This being effected as explained, the shaft has to be correctly centered. Two light centre-marks are again knocked into the two ends of the bar, which is then placed between the lathe-centres, as before; but for the ordinary plain screw headstock centre is substituted a cutting centre—that is, one with its cone filed down to four cutting edges—and this is only gently forced against the bar so as to allow of its being easily rotated.

A driving dog or carrier having been slipped upon the bar and adjusted, and a flat-faced non-cutting tool placed in the slide-rest, the lathe is set in motion, and a little oil dropped on the point of the cutting centre. The flat face of the tool is simply used to apply pressure. It is placed just at the end of the shaft, and carefully brought up against its surface as it rotates. If the centre-mark knocked into the end of the bar be not in the centre of its face, the shaft will run out of truth or excentric, and the object of pressing a flat-faced tool against it is merely that the tool coming first of all in contact with the place farthest from the correct centre may force that part inwards, and oblige the cutting centre of the lathe to cut its way towards the place to which the pressure is applied. The tool must be very gradually forced against the shaft, and simultaneously the cutting-centre must be forced against the end; but until the correct centre of the bar is found—which is seen by the tool pressing about equally around its periphery—only enough pressure should be applied to the cutting-centre to keep the bar fairly in its place, and prevent it falling from the lathe-centres. When, however, the cutting-centre has arrived in the centre of the bar, it may be pressed up to its cut with greater force until it has scraped out a pit deep enough for the bar to be turned on. The proper depth of the centre-mark depends upon the size of the work; but it is not a matter needing any great degree of exactness.

One end of the shaft being centered in this way, the lathe is stopped, the carrier slipped along to the opposite extremity, and the position of the bar in the lathe is reversed, in order that the same operation may be performed on its other end.

It is usual, after the bar has been square-centered, to drill a very small hole up each end at the bottom of the centre-mark; this may be done in the lathe or not, as may be most convenient. The size of the hole generally varies in diameter from, say, one-twentieth of an inch to one-quarter, and from three-sixteenths of an inch to one inch in depth, according to the size of the shaft. The chief function of these holes is to carry oil for lubricating the centre, and to prevent the extreme points of the lathe-centres from coming into contact with the metal.

The next point to attend to is that of straightening the bar, and when this is effected it is ready for turning. It is, of course, assumed that the shafts are not brought to the lathe with any considerable deviation from the straight, as rough straightening should be performed in the forge, and always previous to the final centering of the bar. The turner has frequently, however, to remove some slight bends from his work which would perhaps otherwise prevent it from holding up to size. And this more exact straightening is not quite so easy to perform as a looker-on would imagine. Some workmen will straighten a shaft with a few blows, and in as few minutes. Others will perhaps hammer away for an hour upon it, and leave it worse than when they commenced. And occasionally a single tap with the hammer may chance either to suddenly rectify a shaft which had almost exhausted the workman's patience, or it may as suddenly and as inexplicably throw out of straightness one that apparently needed but this single blow to render it perfect. The usual method of straightening is very simple. The shaft is mounted between the centres, and is moved round slowly, whilst a piece of chalk is carefully applied at those parts where the excentricity is greatest. When the lathe is stopped the workman observes the position of these chalk marks, and if they are all on the same side of the bar, he concludes that he has only one bend to straighten; whilst if these chalk marks are disposed around the bar, or at opposite sides of it, he knows that he has to rectify two or more distortions.

A single bend is easily put straight, but when there are more there is a chance of throwing one place out whilst hammering another straight. If there be only one bend in the shaft, the workman places a block of wood on the lathe-bed just underneath the spot he judges to be the origin or middle of the bend; he takes a small iron bar as a lever, and using the block of wood for a rest or fulcrum, he applies such a pressure to the under part of the shaft as in his judgment the extent of the bend may demand. The end of the lever, which should be flat, is applied to the same side of the shaft as the chalk marks, the shaft being shifted round to bring that side undermost. It is not upon the unaided pressure, however, that the workman relies, but at the same time as he presses upon the lever with his left hand he plants a blow with a hammer upon the shaft at a point as nearly as possible opposite to that in contact with the lever. The heaviness of the blow is a matter of importance, but of this, also, nothing but experience will enable one to judge.

After this the lever is removed, and the chalk is again used to indicate the position of the bend and the effect of the blow. If the marks repeat themselves on the same side of the shaft, this shows that the treatment was not sufficiently severe; if they appear all on the other side, it was too severe; and if some are placed one side and some on another, the effect of the blow has been to knock a simple bend into a compound one. The treatment must be continued according to the judgment of the workman until the shaft is straight enough for turning up. The chief points upon which success depends are the position of the end of the lever, the pressure applied, and the weight of the blow. With all three correct, a single blow will straighten the bend.

The shaft being properly centered and straightened, it is ready for turning. A carrier is fastened upon one end of the shaft, which is placed again between the lathe-centres, and a tool is fixed in the slide-rest, and the latter is moved along the bed, so that the tool may commence at the extreme right hand of the shaft. The bulk of the metal should be removed at the first cut, and a second or at most a third cut should finish the shaft. But the

whole length should be roughed over before a finishing cut is taken.

The circumferential speed, the shaft being good wrought iron, should be about 18 or 20 feet per minute; the traversing speed of the tool should be about fifty cuts to the inch—that is to say, the work should rotate about fifty times whilst the tool travels one inch; and the edge of the tool should be kept well lubricated and cooled by the continuous dropping upon it, from a can placed at a slight elevation, of soda-water or soap-suds. If the shaft be long and slender, the back-stay of the slide-rest will have to be used to hold the shaft in position against the cut, which tends to force it out of line. This stay is generally adjusted to follow the tool, but it may be fixed to precede it in such cases as where the surface of the work has been previously rendered quite true. But the latter disposition, although sometimes convenient, is not a usual one.

After the shaft has had a good stiff roughing cut removed from it, from some cause or other, it is generally left much bent and distorted. This is at once discovered on rotating it freely without the back-stay and out of contact with the tool, when it is very frequently found that the shaft runs considerably out of truth, and requires as much straightening as it did to prepare it for the lathe in its rough bar form.

The re-straightening is performed in the same manner as before, but it will be found that a less pressure upon the lever and a lighter blow with the hammer are now sufficient to correct a given distortion.

The finishing cut is taken in the same way as the roughing cut, but greater care should be exercised in sharpening the tools and in conducting the operation generally. Sometimes the finishing cut is taken with a peculiar form of tool, called a spring tool, from its being so shaped as to spring away from the cut if any great resistance be encountered, which takes the merest scraping of a cut, and if well sharpened and well lubricated with the water, leaves a very smooth glossy surface upon the work, instead of the slightly roughened surface left by the ordinary turning tool. Shafts are, however, usually polished either by removing the traverse marks with a file and then grinding with emery and oil, or in certain cases by grinding the surface at once by the application to it of a rapidly rotating emery wheel, the shaft itself being meanwhile slowly revolved. The two end-faces of the work need very little doing to them, but this little should be effected previous to polishing by just skimming them over with a sharp knife-tool kept well wetted so as to leave a polish.

Turning of every kind is practised much in the same way as that described, but the work may have to be fastened to the lathe differently, and the preliminary adjustments may not be the same. For instance, in turning up a plane surface, say a flat disc, the object would either be fastened by bolts or clamps to the face-plate, or held in the four-jawed chuck, whichever might be found most convenient. If the disc be tolerably thick, and with a hole through its centre, it is generally advisable to drive it on a steel mandril, as in that way the turned portion will be true with the hole itself. The traverse of the tool for this class of work is derived from the cross slide of the rest, and the direction in which it moves is from the centre towards the circumference. In order to keep the cutting speed about constant, it is necessary to run the lathe slower as the tool recedes from the centre, because with the same speed of the lathe the cutting speed is obviously increased as the tool approaches the circumference of the circle. The alteration of the lathe-speed is of course effected by shifting the driving-band on to a larger step of the cone-pulley upon the lathe-spindle.

A flat ring or socket is first bored out to the required size, and if necessary the hole is smoothed or polished by grinding with emery upon a leaden lap. The rough ring is then driven upon a mandril, and its face is turned down to its size, after which the two edges or sides are faced up with knife-tools.

A steam-engine connecting-rod is made larger in the middle than at the ends, and the longitudinal section is sometimes bounded by two curves of high radii, and sometimes by four straight lines forming portions of a double cone. To turn a rod with a curved "belly" needs a special motion of the tool, and this cannot be obtained without special mechanism. But when, as is very often the case, the rod increases in size regularly towards its middle, it may be turned in an ordinary self-acting lathe by moving the right-hand lathe-centre out of its true centre-line. When both centre-points are in their usual position the point of the tool, in running along the bed, will describe a line parallel with the line joining the two lathe-centres; but when one of the lathe-centres—say the right-hand one—is moved out of the true centre-line, the line described by the tool's point is no longer parallel with the new line joining the centre-points, but forms an acute angle with it. If the connecting-rod be in the lathe, and the turner begins as usual at the right-hand end, the lathe-centre at that end is shifted a little nearer the tool. Under this arrangement, as the tool travels towards the other headstock, the distance of its point from the line joining the two centre-points will become greater, and as this distance forms the radius of the turned circle, the diameter of the connecting-rod will also increase so as to form a tapering rod. When one-half of the connecting-rod has been thus turned, the rod is reversed, and the other half turned in the same manner. The actual distance the lathe-centre must thus be thrown out of its line in order to produce any given taper is generally a matter of experiment. The workman commences with a certain distance, and he judges from the cut whether this is too little or too much, increasing or reducing it as he finds necessary. The exact distance necessary depends upon several conditions which may vary for each end of the same rod.

An excentric for moving the valves of a steam-engine is another article which needs a little care in turning it. The excentric-hole is first bored out in the lathe whilst attached to the face-plate. This allows a mandril to be passed through it, when it is placed between the lathe-centres, and the flat sides of the excentric are faced up just as though it were a circular disc. Thus far is plain sailing, but the edge of the excentric cannot be turned upon the same centres; so it becomes necessary to find two others which will bring the edge concentric. If the hole through the excentric be large, or the excentricity small, the two new centres may fall within the ends of the mandril; but if they do not, two collars have to be fastened upon the mandril, one at each end, to receive the new centre-points, and upon these the edge of the excentric is turned to shape. The greatest care must be taken in locating the new centre-marks, or the excentric will run out of truth, and give trouble when working. Their correct position is found by taking the extent of excentricity between the points of a pair of dividers, and with this as a radius, and from the centre-marks of the mandril, describing or scratching an arc upon each end of it. This shows the distance of the new centres from the true ones. The direction of the excentricity is found by placing the mandril in the lathe with the line joining the two centres of the excentric horizontal, and striking a horizontal line upon each end-face of the mandril with a properly-adjusted scribing block. The greatest care must also be taken, whilst turning up the excentric, that it does not slip round upon the mandril, as this, by altering the relative positions of the several centres, necessarily throws the work out of truth.

In turning out an ordinary screwed bolt the workman first turns the blank bolt to its proper size, making a round-bottomed groove in it at the place where the screw-thread has to terminate, of about the same depth as the screw-groove, but no deeper, or the bolt will be unnecessarily weakened. The ordinary traverse is not deep enough for cutting the thread, so the change-wheels of the lathe must now be called into use to move the tool instead of the usual mechanism, that is, supposing the lathe has both sliding and screw-cutting apparatus. The lathe leading-screw has, say, two turns per inch or half an inch pitch, and the thread to be cut upon the bolt is to have eight turns per inch; then we must connect the lathe-spindle to the leading screw through such a train of wheels as will drive the leading screw round twice whilst the lathe-spindle and work rotates eight times. A pinion of 20 teeth on the lathe-spindle gearing into a wheel of 40 teeth on the intermediate socket will drive the socket round half as fast as itself, and a wheel of 60 teeth on the same socket gearing into one of 120 teeth on the leading screw, will reduce the speed of the latter again by one-half. With this train of wheels, whilst the lathe rotates eight times, the intermediate wheels will rotate four times, and the leading screw will rotate twice, which is what is wanted to cut a thread of eight turns to the inch.

The tool must be shaped to suit the thread. It should be kept sharp and well lubricated at its cut, or bad work will be

produced. When the tool reaches the groove cut as before instructed, it is withdrawn from its cut, and run back again by reversing the lathe, as already explained. To cut up the thread of a screw, of, say, twenty threads or complete convolutions to the inch, the lathe must rotate twenty times whilst the tool travels one inch, and with a pitch of two to the inch the leading screw will require to rotate twice to produce that extent of movement. A train of wheels must therefore be arranged to give the leading screw two rotations to twenty of the lathe. A pinion of 20 teeth on the lathe-spindle gearing into a wheel of 50 teeth as an intermediate, and a wheel of 30 teeth on the intermediate socket gearing into one of 120 teeth on the leading screw, will answer this purpose, as $20 \times 20 \div 50 = 8$, which is the number of times the intermediates will rotate to twenty of the lathe-spindle, and $8 \times 30 \div 120 = 2$, the number of rotations of the leading screw when driven from the spindle by these wheels.

In the same way, to cut a screw of the same pitch as the leading screw of the lathe in use, the spindle and the screw must have equal angular velocities, and a pinion of 40 teeth will be placed upon the lathe-spindle, and another of the same size on the leading screw, any large wheel that will gear with the two being used as an intermediate.

To cut a spiral of one complete turn in $2\frac{1}{4}$ inches with a two per inch leading screw the lathe must make one rotation whilst the tool travels $2\frac{1}{4}$ inches, and to cause this travel the leading screw must rotate $2\frac{1}{4} \times 2 = 4\frac{1}{2}$ times. The wheels must therefore be such as will give $4\frac{1}{2}$ turns of the leading screw to one of the lathe, or 9 turns to 2.

In this case the driving-wheels must be larger than the driven, as the speed has to be raised instead of lowered, in the proportion of 9 to 2. A wheel of 90 teeth on the lathe-spindle, and one of 20 teeth on the leading screw, with an intermediate to connect them, would give the speed, but it is generally preferable to use larger driven wheels, and to divide the difference between the drivers and the driven wheels amongst the two sets, so that a pinion of 100 teeth on the lathe-spindle gearing into an intermediate of 50 teeth, and an intermediate of 90 teeth gearing into a wheel of 40 teeth on the leading screw, would be a better train for the purpose.

Lathes are generally furnished with the following wheels, which are sufficient for almost any pitch—viz., 20 (sometimes 21, 22, 23, 24), 25, 30, up to 120, rising five teeth to each wheel, with an extra 40-tooth wheel for equal speeds. This makes 22 wheels, which is considered a full set. The four wheels between 20 and 25 are useful for odd pitches, and although very seldom needed may chance occasionally to save a good deal of trouble.

The pitches most often wanted are those for the ordinary Whitworth standard screw-threads of 20, 18, 16, 14, 12, 10, and 8 turns to the inch, and 4, 2, and 1 to the inch for lathe leading-screws. These pitches are all easily obtained by simple mental calculation; sometimes, however, odd pitches are met with for which the proper wheels are not so obvious; but the following rules, taken from the author's treatise on "Lathes and Turning, will remove any remaining difficulty:—"The pitch of the required screw, divided by the pitch of the leading screw, will give the ratio of the number of revolutions of the leading screw to the number of revolutions of the lathe-spindle. Thus, supposing a pitch of seven to the inch to be required, the number of revolutions of the lathe-spindle will be seven to four of the leading screw, the lathe having to revolve the number of threads in the inch of the required screw whilst the leading screw revolves the number of times necessary to move the tool one inch. Knowing the ratio the speed of the screw bears to that of the work, it is an easy matter to calculate the wheels which will give these speeds.

"Many workmen can calculate the changes required for any whole number of threads, but cannot do so for any broken or fractional pitches. In reality fractional pitches are almost as easily calculated as whole numbers. We have only to multiply the fractional pitch by any number that will eliminate the fraction, and then to multiply the number of threads of the leading screw by the same number; the two numbers thus obtained will be the number of revolutions as before. For example, suppose we require to cut a screw having a pitch of $1\frac{3}{10}$ inch. Then $1\frac{3}{10}$ multiplied by 10 is equal to 13, which is the number of revolutions for the lathe-spindle.

"Also 4 multiplied by 10 is equal to 40, the number of revolutions of the leading screw.

"Again, if we want a thread of $\frac{3}{22}$ of an inch—

"$\frac{3}{22} \times 22 = 3$, number of revolutions of lathe-spindle.

"$4 \times 22 = 88$, number of revolutions of leading screw."

These examples were calculated for a leading screw having four turns to the inch.

SOLDIERING.—VII.

BY A STAFF OFFICER.

TRAINING (*continued from Page* 219).

It follows from what we said about the formation of troops at the end of our last paper, that if a small body of troops gets into a position towards the flank of another, it has acquired an immense advantage over it. For instance, from the position C D (Fig. 6) men could bring a tremendous fire to bear on A B, while A B would have very great difficulty in replying to it at all. It would, in fact, be necessary to get A B into a new position, more nearly parallel to C D, or in its turn taking C D in flank. The difficulty of performing this latter operation is, of course, enhanced by the fact that it must be undertaken under very effectual fire from C D. Hence it is easy to see that it will be constantly necessary to take care that troops are not exposed to the risk of being "taken in flank." Now the formation of bodies "in echelon" securely protects one flank, and as we can usually be pretty sure from the nature of the undertaking which flank is most exposed to risk, this in fact is, as a rule, sufficient.

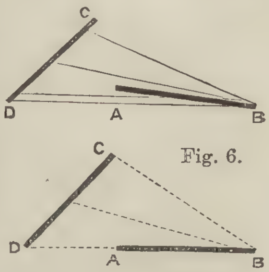


Fig. 6.

There are three kinds, as shown in Fig. 4 (p. 216). Short echelon protects both flanks to some extent. Direct echelon protects the flank which is thrown back—the right, for instance, in the illustration. In oblique echelon, similarly, the flank thrown back from the general position of the echelon, but that which is, in fact, thrown forward in making the movement, is protected. In the illustration this is the left flank. How this protection is afforded is evident, for each small portion would be protected from any enemy assailing the flank I have in each case named, by the fire of the portion next behind it. The near one is not directly protected, but is the furthest from the enemy. In oblique echelon we have the advantage that the line is gradually being transferred during the process of the movement to a position to the right or left of that which it formerly occupied. When the whole body has arrived at the required position, line is easily re-formed again either into the original direction of front of the line, or into the direction of front common to each separate portion of the echelon, or to a front more or less oblique than that of the echelon.

It should be observed that the word "front" is used in somewhat different manners. It is used in its simplest sense to imply that portion of a position occupied by troops which is nearest to the enemy. Then from the fact that positions are in general taken up by armies in successive lines, it has come to be used of the general *direction* of the line running along the part of the position or formation supposed to be nearest to the enemy.

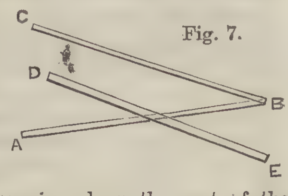


Fig. 7.

It is in this sense of the word that we speak of a "change of front." We mean that we change the direction of the line running along that part of the formation of the troops which we intend to be nearest to the enemy. Then again the word is used as a sort of abbreviation of the expression "length of ground taken up from one flank to the other by the troops occupying the front (in the first sense of the word) of the position (or formation)." Thus troops which when in line occupy from one flank of the line to the other 1,000 yards, are said to have "a front of 1,000 yards." The difference between a change of position and a change of front is that in the case of

a "change of position" the whole body of troops occupying the front is transferred to a new position, no part of which has been occupied by any part of the line in the original position: in the case of a "change of front," the new front either intersects the old, or meets it in some point without intersecting it. Thus to transfer a body of troops from D E to C B (Fig. 7), or from C B to D E would be to "change position." A change from A B to either C B or D E, would be a "change of front." Thus a change of position may or may not involve a change of front also. The front of a new position may be parallel to the front of the old position or oblique to it.

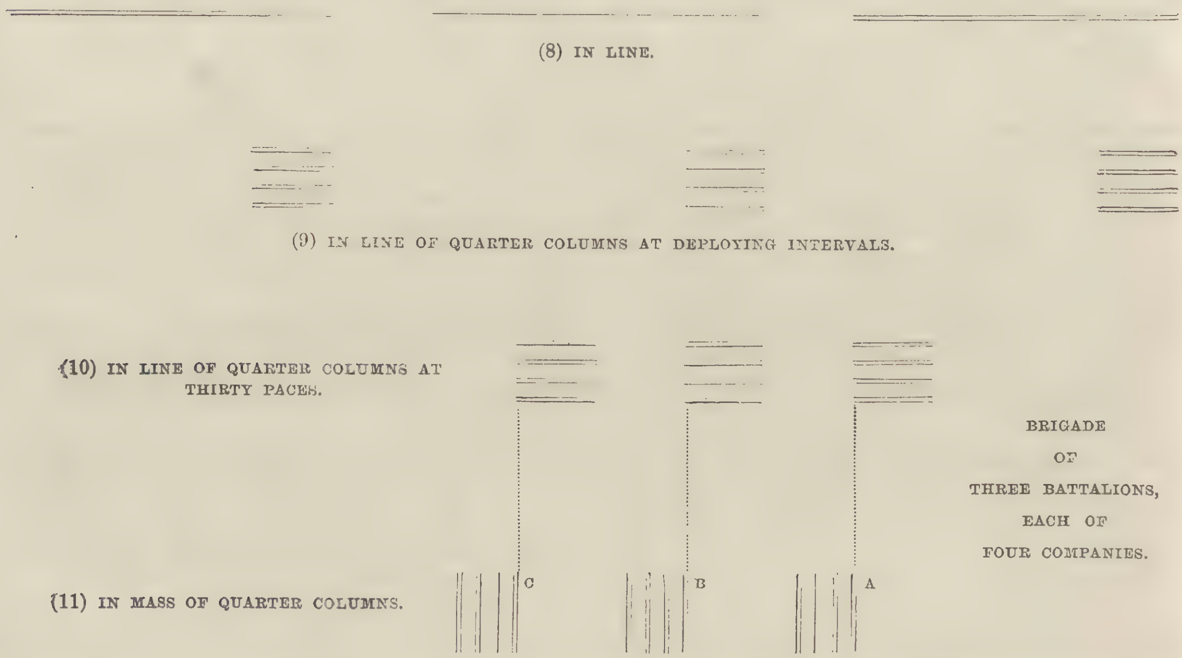
This will be sufficient for our purpose in regard to infantry drill.

When bodies of infantry larger than battalions are brought together for purposes of drill, two or three battalions are usually formed into a "brigade," two brigades into a division, and two or three divisions into a *corps d'armée*. These large bodies require to be able to form lines and columns just as the smaller do. In their formation there is this difference, however. The battalions are themselves when in line so formed that each man stands shoulder to shoulder, and no space is left from one flank of the battalion to the other, a space of forty-eight inches being allowed for each officer in the line just as for each man. But when several battalions are placed side by side one another an interval of twenty-five yards or of thirty paces is allowed between each battalion and the next. The battalion is usually—partly on this latter account, partly for the reason already named, that its force was originally determined by getting the largest number of men together to whom one man can issue personal orders by word of mouth—called in infantry the "tactical unit," or unit of manœuvre. The expression is often used, and it is therefore, perhaps, better to mention it here, but the name is a singularly unpractical one, for each portion of an army needs to be a unit, so far as complete harmony of action is concerned, yet in each portion there must be many subordinate parts, each in its degree independent.

Lines of "quarter-columns" are often formed. These are so arranged that the leading company of each battalion is in line, and that the different columns are either thirty paces apart, or at such distance that there is just room between each two quarter-columns for the column to "deploy into line" (that is to say, to form line on its leading company, fronting in the same direction as that in which the column fronts), or the line of columns may be so formed that the columns are at any intermediate distance apart greater than thirty paces, and less than deploying intervals.

Since our object when moving in column is always to be able readily to form line, it follows that in the columns formed of great bodies of troops care must be taken that space is left sufficient to allow of the line being formed with the proper intervals between battalions. Hence, when a large body of troops is moved in columns of companies, it is necessary that space should be allowed between each two battalions sufficient for the leading company of each battalion to be wheeled on its pivot, leaving room in addition for the interval of thirty paces between battalions.

Similarly, in what is called a "mass of quarter-columns"—that is to say, in a column so formed of quarter-columns that the column can become a line of quarter-columns by each quarter-column wheeling to the proper flank—it is necessary that there should be between each two columns a distance equal to the front of the leading company of the battalion following, and thirty yards. This is easily seen on comparing Figs. 10 and 11 in the annexed diagram.



It ought to be noticed, before leaving this part of the infantry drill, that in order to resist cavalry, "squares" are formed in which sometimes the ranks are two deep and sometimes four deep. It is not indispensable to form square on all occasions to receive cavalry now that firearms are so deadly. On the contrary, under ordinary circumstances, where the ground is open and the cavalry can be seen beforehand, they can be repelled by infantry in whatever formation they may be. But the danger to which infantry is exposed by the attack of cavalry is, that the latter by its greater rapidity may work round the flank and come down on the rear of the infantry. Hence, if infantry is caught unexpectedly by cavalry, it is obliged to assume a formation in which it can resist attack from whatever direction it may come. It is no longer necessary, as it used to be, that the squares formed should be always large. They are often of much smaller bodies than they formerly were. To this subject, however, it will be necessary to recur in speaking of the form of fighting which has now become almost inevitably the normal one, and the preparation for which can scarcely in strictness be called drill. This form is that known as skirmishing. In order to make clear the distinction between the nature of the past and of the present, it will be better, however, before speaking of skirmishing, to go through the broad points of the drill of the other two arms.

FARMING AND FARMING ECONOMY.—XX.

By Professor Wrightson, Royal Agricultural College, Cirencester.

SHEEP (*continued from Page 239*).

Cheviot sheep may be described in general terms as a white-faced, middle-woolled race; the males horned and the females hornless; adapted for the severe climate of the Cheviot Hills and for the lower slopes of the Highland mountains, wherever grass does not give way to heather. An attempt was made by Sir John Sinclair to supplant the Cheviot by means of Southdowns, but the climate was too severe for the hardy little south country breed. Cheviots, too, have been introduced into the true home of the Scotch Black Faces, but although successful during ordinary seasons, a severe winter upon those high-lying and exposed lands proved to be too much for them. Crossed with Leicesters the Cheviot sheep form a most invaluable breed, which occupies a large portion of the border counties. When purely bred, the Cheviot sheep is not fatted the first winter, but is reserved to be finished upon grass at eighteen months old, or is carried again on to turnips, and made ready for the butcher at two years old.

The Scotch Black-Faced sheep is sufficiently hardy for the most exposed Highland runs. It is a long and somewhat hairy woolled sheep, although a good specimen should be free from "kemps" or grey hairs in the fleece. The head, which always gives the character to every kind of domestic animal, is black and white, the "paintings" or markings of these two colours being, in the best examples, distinct and not running into each other. The horns are finely convoluted, and spring from the forehead, passing backwards before turning, in exactly the same plane with the forehead. The space between the horns and on the back of the head is covered with fine hair rather than wool. The Black Faces are found on the moors of Yorkshire and the more northern English counties, but are too restless for confinement in arable and fenced districts.

Such are the principal British breeds of sheep. There are, however, two or three others which deserve a passing notice as peculiarly adapted for certain localities. Among these the Herdwicks of Westmoreland and Cumberland occupy a place. These sheep are said to have found their way on to shore from a ship wrecked near the coast, and bear a striking resemblance to a Welsh breed, from which they are probably an offshoot. The Herdwick was soon found to possess valuable properties fitting it for its new home. An association was formed for improving the breed, and annual shows were founded for encouraging the best type.

The Herdwicks occupy the high mountain region of Langdale Pikes, Scaufell, Wasdale, and Hornster Crag. Their appearance is singular. The rams are horned, while the ewes are hornless; the face and legs mottled; the wool somewhat coarse, and longer and darker in colour round the neck, giving the idea of a mane. They clip from 5 to 6 pounds of unwashed wool, which, in July, 1869, sold for about 8d. per pound. The Herdwicks come to maturity at four years old, when they weigh from fourteen pounds per quarter of mutton of high quality. The usual lambing season extends from mid-April to mid-May. The lambs are brought from the hills at Martinmas, and are placed on lower ground, returning to the hills in April. They are sold when about four years old, at Cockermouth and Keswick fairs, to the lowland farmers, who fatten them on turnips.

SOUTHDOWN SHEEP FROM THE FLOCK OF MR. JONAS WEBB.

The Lonks are peculiar to East Lancashire and West Yorkshire. They, together with the Crag and Limestone breed, are useful upon two classes of land, the one low-lying and moory, the proper habitat of the Lonks, and the other adapted for the dry and high-lying mountain limestone moors. The first breed can withstand the effects of damp, the second can do almost without water. They are therefore exceedingly useful in two opposite conditions of soil and climate occurring within a very short distance of each other. The Lonks are black and white faced, horned and moderately woolled; the Crag or Limestone sheep are white-faced and horned. Specimens of Crag sheep, exhibited by Mr. Rowland Parker of Moors End, Pourton, Westmoreland, at the Manchester Exhibition, 1869, were thus described by the present writer:—Both sexes horned; face and legs white; wool firm, intermediate in length, and inclining to the character of short, rather than of long wool. Mr. Parker's flock clip on an average 7 pounds each sheep, and 1s. 3d. per pound was realised in the season of 1869. Mr. Parker rears and feeds off his wether lambs entirely on the lower "inland" ground, and raises them to from 18 to 22 pounds per quarter at

twenty months old. The ewe lambs are kept on the "inland" until they are one year old, and then go to the "common" or high ground from May to October. They are again brought down in October and put to the ram. Mr. Parker speaks to the prolific character of the females. Out of fifty-four ewes thirteen produced three lambs each, while the entire fifty-four brought up ninety-six to weaning-time.

MANAGEMENT OF SHEEP.

This subject may be conveniently divided into the breeding, rearing, and fattening of sheep. So much might be written upon these three sections that we confess to a feeling of great difficulty in selecting those points most likely to give a good general idea of what is meant by each. Breeding entails a ewe flock, and we propose to sketch the salient points in the management of this important part of the farm stock, and, following the lamb from birth to the time it is fatted off upon turnips, to give a general view of the three principal branches of sheep management. Sheep-farming may consist of the breeding of lambs to be sold in the autumn to lowland graziers, and this form of husbandry is usually seen on high poor lands, fitted for rearing rather than fattening animals. A second plan is to buy lambs or lean sheep and fatten them, and this is generally carried out upon good land. A third method is to keep ewes, rear lambs, and fatten them at about one year old. This system is in vogue upon the chalk and oolitic ranges, and wherever land is of light texture and fair quality. The disadvantage of keeping a ewe flock upon really good land is, that ewes require to be kept comparatively poor during a considerable portion of the year, a condition which it is difficult to observe upon good land. Consequently, in such situations ewes are liable to be fat during the whole season, and this is neither advisable nor economical. An intermediate plan may, however, be adopted on such good lands by keeping what is called a "flying flock." By this is meant the purchasing of "cull" or old ewes from some good breeder, taking one "crop" of lambs off them, and then fattening the ewes. The lambs are also fatted, so that new faces are brought into the farm every year. This is a plan which, it will be seen, is inconsistent with the idea of improving a flock so as to bring it up to a high standard of merit.

In tracing the history of a ewe flock throughout the year, we shall follow the ordinary Cotteswold practice, endeavouring to point out any differences of importance between it and that of other good sheep districts. The year is best commenced after weaning-time, when the ewe flock may be considered as commencing another definite period. Immediately after weaning the ewes are put on to dry and poor pasture, firstly to dry up their milk, and secondly for the sake of economy. This is done about the middle of May or first week of June; but the exact period varies. The lambs are best weaned when from nine to ten weeks old. The ewes are frequently run over the grass land, being employed to eat down the ley lands bare that are intended for wheat. They are thus kept until within a month of the time that the ram is put among them, when, if necessary, they are placed upon somewhat better keep, so as to freshen them up a little. It is considered that this ensures a better crop (as it is often called) of lambs than if the ewe conceives while in poor condition. This brings us to September or October, according to the system adopted. In the case before us the 25th of September is a very frequent time. The rams are selected with a view to correcting any faults of the flock, and generally of improving it, and one ram is sufficient to impregnate sixty ewes, although a greater number are often allotted to each ram. Ram lambs are occasionally employed, especially in Hampshire Down flocks, but yearling and two-year-old rams are more ordinarily used. The proper age to place a ewe in the flock is eighteen months, or the autumn after she is one year old, and as a general rule she remains in the flock three years, when she becomes a cull. There are advantages in "culling" the ewe flock "close" or keeping it young, as by so doing the cull ewes will fatten more readily at home, or command a higher price if sold for breeding purposes. It is the object of the flock-master to keep his ewe flock young and vigorous, as well as to improve it as a breeding stock. To this end the flock is weeded, not only of old ewes, but of all defective animals, and, as far as possible, a uniformity of type is secured throughout the flock. After the ram is removed, the ewes are run upon old seeds, stubbles, and grass land, until late in the year. No limit of time can indeed be fixed; for, should the weather remain open, ewes will do much better upon such keep than folded upon roots. Severe weather, and especially snow, will, however, frequently compel the farmer to either fold his ewes, or cart turnips and hay to them upon grass, which last method is to be preferred. Some shepherds are in the habit of allowing their ewes a full allowance of turnips or other roots even in the coldest weather, but this seems hardly reasonable when we remember the large proportion of water, then in a frozen condition, which such roots contain. A much better plan is that described by Professor Coleman in the volume of the *Royal Agricultural Society's Journal* for 1865, where he gives an instance of a Hampshire Down flock which was allowed to run on grass during the day, and was folded on pasture at night. The ewes received in the morning and at night an allowance of trough food, consisting of straw and hay chaff, bruised oats, and palm-nut-meal, at a cost of $2\frac{3}{4}$d. per head per week. Mr. Wilson, of Edington Main, recommends one measure of pulped roots and one measure of chopped straw; and this will be found better than a very liberal and unrestricted measure of frozen turnips.

As lambing time approaches $\frac{1}{4}$lb. of cake or corn may be added, and the "theaves" or young ewes will receive a little more indulgence than the older portion of the flock. The lambing season commences in the case before us towards the end of February, and on all Cotteswold farms the ewes are lambed down in a comfortable enclosure constructed of thatched hurdles, the enclosed space being well littered with straw and furnished with small pens for the reception of lambing ewes. This is an engrossing part of our subject, and to give a full description of all the difficulties and methods connected with the management of a large ewe flock at this critical part of their history would demand much more space than is allowed us. The utmost vigilance, day and night, is required on the part of the shepherd, as well as considerable obstetric knowledge. Supposing, as is usually the case, that the lamb is safely born, three days will place the ewe out of all danger from inflammatory attacks, and, should the weather be favourable, she and her lamb or lambs may then be turned out during the day-time. In hard weather shelter at night is still desirable, but in ordinary cases, if the ewe has a good supply of milk, the lamb will be able to withstand the rigours of climate with great hardihood. In a fortnight it will begin to seek other nourishment than that supplied by its dam, and very shortly it will take advantage of the "lamb hurdles," which should always be provided, to run forward and browse upon the young shoots of the swedes or turnips. In the management of sheep from birth until they are ten months old, which is about the time that they ought to be ready for the butcher, not an opportunity must be lost of encouraging their rapid growth and development. We would lay especial stress upon the importance of frequent changes of food, of the early use of dry food in the form of cake or corn, of a supply of water, and of careful watching against the attacks of flies, which are apt in the summer to deposit their maggots in the wool of sheep, and thus to cause them serious annoyance. "We must bear in mind," says Mr. Edmonds of Southrop, a member of council of the Royal Agricultural Society and a leading agriculturist, "that if by care and good living we can make 10 or 11 stone weight each of our young sheep some time in January—that is, from ten to eleven months old—we can keep a heavier breeding flock, and by that means make more mutton and grow more wool than we could if by less liberal living we were unable to dispose of them before March or April, or, as is the case in many instances, even later. Now, how are we to attain so desirable an end? I believe only in this way—by not only preventing our lambs from losing flesh, but by doing our utmost to make them gain flesh, from the very moment they leave their mothers. . . . Even for two or three weeks before they are weaned, I would recommend a small quantity of pea-meal or oil-cake dust to be given, just to use them to it; then, as soon as they are weaned, two ounces of cake or split peas each (I prefer oil-cake). From that time until August their other food will consist of grass, vetches, and latter-math clover—two kinds of food are best; then rape and vetches, or rape, until the time comes for them to be cautiously put on to turnips. Towards the end of August, or even before, unless the weather is very hot, I would add to the other food a

quarter of a pound of cracked beans each, and, as the season advances, increase by degrees the oil-cake until it reaches ¾lb. each, if straw-chaff be given, but if a fair proportion of good hay, I think ½lb. would be ample. By such living, sheep may be brought to good weights, fat, yet with plenty of flesh, at eleven if not at ten months old, without forcing so as to produce disease, and without extravagant living."

PHOTOGRAPHY.—XIII.

By J. C. Leake.

LANDSCAPE WORK.

In a previous article we have described the dry-plate processes most frequently employed in the production of pictures at a distance from the photographic laboratory; but although these are generally tolerably certain in the hands of a skilled operator, there can be no question that for absolute certainty of result the wet collodion process we have already described is to be preferred. The great advantage of employing the last-named process is that the plates can be developed on the spot, and that consequently, in case of failure, another plate can be exposed without delay, and a picture at once secured. All who have worked with dry plates will readily admit that one of the most tiresome and annoying circumstances attendant upon their employment is the failure of a plate which has been exposed to a subject which the operator has been most anxious to secure, and which in many cases cannot be again attempted. This is the most serious drawback to all dry processes, and therefore, where it is necessary to secure pictures with absolute certainty, the wet collodion process is the only one to be employed.

The great difficulty in the employment of the wet collodion process away from home is the weight and cumbrousness of the apparatus required. Of course a dark room is necessary, in which the plates may be prepared and developed, and this, with the camera and the requisite chemicals, will, where the plates are of anything like large dimension, involve the carrying of an amount of luggage which will in travelling become a burden. In this matter, however, there is no option, and the choice must be made by the operator between the dry plate and its uncertainty, and the wet with its attendant inconvenience and additional labour. Happily, the makers of photographic instruments have bestowed considerable labour and have displayed much skill in the construction of apparatus of a light and portable character for out-door work, and hence the necessary appliances are now not nearly so heavy and cumbersome as heretofore. One word of caution is, however, necessary at the outset, namely, that the operator should, in the purchase of instruments for out-door work, be careful not to sacrifice practical utility for the sake of lightness and portability. Working at home, any little defect of apparatus may be speedily remedied, but in the field everything must be in first-rate order, or some trifling mishap may spoil a day's work. It ought also to be understood at the outset, that in case pictures the size of which exceeds six by five inches are required, the apparatus will be too heavy for one person to carry any considerable distance. Photographing out of doors is hard work at the best of times, and requires that the operator be fresh and vigorous, and it will be found that carrying a heavy package of chemicals and apparatus for a long distance will entirely incapacitate him for the somewhat arduous labours of the day. If such an arrangement can be made, two persons at least should work together, as the operator will need assistance while in the tent. If a horse and cart of some sort can be procured it will save much labour and time, and the additional expense will be amply repaid, both by the ease and comfort with which the work is executed, and by the extra number of pictures which can be made in the time.

Having made these general observations upon the apparatus, it will not be necessary to enter upon further detail in this matter. The operator will find it to be the better plan to consult some well-known maker, who will advise him as to that which will be most suitable to his wants. We may, therefore, at once pass on to the practical details of the work.

Before any attempt at out-door work is made, the whole of the apparatus should be thoroughly tested, in order to ascertain that it is in efficient working order. This may be best effected as follows:—The tent should be set up *in the sun*, in order to test its imperviousness to light. This is most important, as it frequently happens that some small crevice is left through which enough light will pass to fog the sensitive plate. In the tent should be placed the bath with dipper, a broad camel's-hair brush for dusting the plate, the box with the clean plates, and the bottle of collodion. The iron developer and the pyrogallic acid solution for intensifying, with their respective developing glasses, and a sufficient supply of water, should also be provided. The fixing solution of cyanide of potassium need not be placed in the tent, as, after the developer has been thoroughly washed off, the fixing operation may be performed out of doors, although it is better not to expose the plate to the direct action of sunlight. The camera should now be secured to the stand, set up (also in sunlight, for the reason given above), and directed to some suitable object. A plate should now be coated with collodion in the tent, and sensitised in the usual manner. As in landscape work, the plates are usually kept much longer between the sensitising and development than when working in a studio. The utmost care should be exercised in thoroughly draining the plate from the bath solution, or stains will result. A few sheets of blotting-paper should be laid so as to allow of the plate being set up and drained on it, and the back must also be dried by the same means. The plate may now be removed to the slide, and exposed in the usual manner. Of course, during this process the utmost care must be taken to exclude every ray of white light. The curtain which enfolds the operator must be most closely drawn before the plate is immersed in the nitrate bath, and must not be loosened until the door of the dark slide is closed and fastened. After the exposure the plate must be removed to the tent for development, which is effected in the usual manner, exercising the same care in the exclusion of light as during the sensitising process.

It will now be seen whether the apparatus is in good working order. If the plate develops cleanly, and the image is bright and free from fog, this is doubtless the case; but if, as often occurs at first, the plate is fogged and misty, in all probability the light finds admission somewhere, either in the camera or tent. In order to detect the cause and find the source of this, the following course will be best. First, remove the bath and chemicals to the ordinary dark room, and in order to thoroughly test them, take a picture in the usual way. If this is successful, the chemicals are in good order, and the defect is to be sought for and found in the apparatus. The chemicals must therefore be replaced in the tent, and a plate prepared as before, the whole structure having been previously examined for any crevice or orifice through which the light might find admittance. When excited, the plate should be placed in the dark-slide, as if for exposure in the camera. The shutter should now be drawn about half-way up, and a portion of the plate exposed in the tent, as near the window as possible, for four or five minutes. If, upon development, any trace of the shutter is visible, the exposed part of the plate having become darkened, the yellow calico or glass is not sufficiently impervious to light, and must be strengthened by one or two additional folds of yellow calico or paper. Should the plate keep quite bright, however, the defect will most likely be found in the camera.

A plate should be prepared as before and placed in the camera, as if for exposure, except that the cap is not to be removed from the lens. The slide should be drawn up, and the plate left for three or four minutes. If this be fogged, the light finds its way through some aperture, which must be found and stopped. It sometimes happens that when lenses of large aperture are used out of doors the light flares on their surface and causes fogging. These should, therefore, always be shaded, by holding a board or shade over them during the exposure of the plate. Having thus ensured the efficiency of the apparatus, the necessary preparations may be made for actual work; but we should advise the operator to devote at least one day to tent work before attempting to operate out of doors, in order that he may become accustomed to the different conditions under which he will have to labour.

In order to produce good work the utmost care must be taken to provide, before starting, a proper supply of chemicals, and also to do everything that can be done in the way of cleaning plates, etc., so that, upon arrival at the scene of operation, the actual work of taking pictures may be entered upon at once. We will suppose the operator to intend working upon plates of ten inches by eight, and will give an estimate of what will be required for one day's work. Of course, the tent and camera,

with their respective stands and the required screws and fittings, will be the first necessities; and these, cleaned and dusted, together with the lens, may be packed first; next will come the glasses, which should be of patent plate, most carefully cleaned and packed in boxes. It is a good plan to have two boxes, one for clean plates and one for negatives—the latter should be of metal, if possible. As a rule, twelve or fifteen plates will make an ordinary day's work. The silver bath should be one of glass or ebonite, of water-tight construction, so as to avoid carrying an extra bottle for the solution, and an ebonite dipper should be used in case of breakage. This, with a brush, and the glasses used for development, will nearly complete the list of apparatus required. The chemicals will be collodion (say ten ounces), in two separate bottles, in case of accident to one of them; iron developing solution (ten grains to each ounce), twenty ounces; pyrogallic acid solution (three grains), ten ounces. The fixing solution may be made on the spot; a bottle containing cyanide in a dry state should therefore be taken, and a separate bottle for mixing it in as required. A suitable vessel should be provided for taking water; and it is a good plan to carry a ball of string, which may be useful in securing the tent, should the wind be troublesome. A couple of coarse cloths, a towel, and a piece of soap should also be provided, as the bottom of the tent should be wiped out after the preparation of every plate, and the hands thoroughly cleansed and dried. A good supply of blotting-paper should also be taken, for the purpose of draining the plates. If a box can be obtained, having a separate compartment for each of these things, it will be most convenient, as it can then at a glance be told whether or not the equipment is complete. As an additional precaution, a written list should be pasted upon the lid of the box, so that each article may be called over before starting. It may seem that these precautions are unnecessary, but it must be remembered that one item being short the trip will be useless.

Upon arrival at the proposed place of work, a convenient place should be chosen upon which the tent may be erected. It is as well to thoroughly examine the ground before setting up the tent, as it often happens that several pictures may be taken within a reasonable distance, and it is better to have the tent in as central a spot as possible. A shady corner should be selected for the sake of coolness. The bath and chemicals should then be placed in the tent in readiness, and allowed to rest for half an hour, if possible. In this interval the camera may be prepared and focussed, and it will be well to select several views before commencing to operate. Frequently very much more effective pictures may be taken of a scene at one time of the day than at another; this should be taken into account, and arrangements made accordingly. A plate may now be prepared, and a picture taken precisely as has been already described.

In places where water is scarce the pictures need not be fixed in the field, although this is undoubtedly the safest plan where practicable. In this case, after the intensifying solution has been applied, and the plate thoroughly washed, the following solution should be applied:—Glycerine, half an ounce; water, two ounces. The plate should be thoroughly flooded with this, and placed in a metal box. Upon arrival at home the plate should be well washed, fixed, and varnished in the usual manner. Great care will be required, however, in washing, in order to prevent the film from slipping off the glass. Some care is also required in placing a wet plate in the box, or the film will catch in the grooves and become torn. The best plan is to carefully remove the film for the space of a quarter of an inch on each of the sides which have to be placed in the grooves. This will prevent the catching and tearing of the film.

From the foregoing remarks it will be seen that landscape photography is somewhat more difficult, and requires more practice, than those branches which may be executed in-doors. The chief difficulty at first will be found in working in the very circumscribed space afforded by the tent. This, however, is speedily overcome by practice, and if care is taken that each operation is performed cleanly and with neatness, it will be found as easy to work in a tent as in the well-appointed laboratory at home. Two things chiefly are needful to ensure success—namely, that the work be executed without hurry, and with the utmost precaution as to cleanliness in every detail. Both of these are indeed necessary when working in the ordinary dark room, but in the heat of the tent the result of inattention to these particulars is certain and inevitable failure.

HOROLOGY.—II.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

WATCHES: THEIR PRINCIPLE OF CONSTRUCTION.

Construction, in its general sense, implies design and arrangement, and in its application the harmonious adjustment of all the forces in question. Although in horology there are not so many forces to deal with as in mechanical and civil engineering, its difficulties are nevertheless considerable. The watchmaker has to guard against waste of motive force by resolution, or, in other words, against undue pressure and friction, by which the mainspring force is working the destruction of the watch; and he has to control or neutralise every force by which 432,000 distinct and separate movements, performed by an instrument in twenty-four hours, may be increased or diminished by a single one.

In horological construction there are some prominent and definite points, to which all others bear a secondary but fixed relation. The great problem to be solved by horology may be simply defined as the relation of motion to time, in which the balance vibration within a given period forms the unknown quantity to be determined. The balance is made either of steel, gold, or partly of brass and partly of steel. It is circular in shape, and mounted on an axle called the staff, whose ends or pivots run in fixed holes made of garnet, sapphire, or ruby. Attached to this staff, above or below the balance, is a spiral coiled spring, much resembling in shape the mainspring, concentrically fixed, its inmost coil running through and bent round into the hole of a collet or small collar placed over the staff. The outer end of this spring runs through and is fixed into the hole of a stud screwed firmly to a rigid part of the watch.

This spring, called the pendulum or balance spring, does the same office to the balance as gravitation to the pendulum. If the balance is moved to the right or left, the spring is inflected or bent either outward or inward. The inflection of each coil depends on its distance from the centre of motion or balance pivots, the length of the spring as a whole, and the radius of the orbit of its innermost coil, or size of the collar or collet to which it is fastened; and according to the angle of inflection, so will its resistance or accumulated elastic force be. If now the balance be released, the force of the pendulum spring will give it motion, which accelerates its velocity until the balance has passed the point where the spring is in poise. But the conditions are reversed the moment this point is passed. The balance momentum has now to bend the spring afresh, the resistance of which progressively increases until both are *in equilibrio*, and the balance stops. This stop is of momentary duration; the momentum of the balance being now expended, the resistance of the spring becomes again the accelerating force, and another vibration is performed, and so on. A vibration is therefore a single and distinct motion of the balance acted on by the balance or pendulum spring, which commences at and finishes with a stop, and the duration of which depends upon the ratio of balance, momentum, and strength of spring. The balance varies in watches, being designed to make from 240 to 300 vibrations per second, or 14,400 to 18,000 per hour. The correct performance of a watch depends on the balance making the vibration it is designed to make in a given period; the hands merely register them, and will move faster or slower, as the balance vibrations are above or below the proper number.

So far we have simply considered the balance vibrations in their relation to time, assuming they are kept up, which keeping up or continued reaction is, however, not a spontaneous act of the balance. If we take a lever watch, not wound up (with a chronometer or duplex this experiment is not advisable), and by a shake or twist of the case set the balance in motion, we find that each vibration is a little shorter than the preceding one, until the last has died off. This gradual cessation is caused by and proportioned to the amount of balance momentum expended in overcoming resistance; and, therefore, to keep the balance in motion, we have to impart a continued fresh supply of momentum, such fresh supply being given by the contrivance called the escapement. As it is the uniformity of the duration of the vibrations that is the element of true time, it is obvious that they should be as free as possible. It is the relation existing between the escapement and the balance, the more or

less perturbing influence of the former on the latter, that establishes the merit of the various escapements, and according to which they stand in the following order, namely :—

1. Chronometer.	3. Duplex.
2. Lever.	4. Horizontal.

The lever escapement, being the most popular, will receive our attention first. The four escapements are ranged in two classes, namely :—

1. Detached, comprising the Chronometer and Lever.
2. Undetached, comprising the Duplex and Horizontal.

It may be as well to state here that there is yet another escapement in use—namely, the verge, which, by reason of its inferiority and impracticability for watches of modern requirement, we have not thought needful or desirable to write upon. The difference between detached and undetached escapements consists in the mechanism by which the force in the escapement is completely locked off during the interval from one impulse to the other, and during which the arc of vibration is free.

In the second class the escape-wheel presses continually against the staff in the duplex, or cylinder of the horizontal, under which pressure the vibration takes place, and has a very perturbing effect. A source of evil in the detached escapement is the contrivance by which the latent force in the escapement is relieved or unlocked. This is effected by the balance at the expense of its momentum, and proportioned to the amount of force to effect such unlocking. The undetached escapements are free from this error, as the escape-wheel is constantly pressing on the staff or cylinder; it is relieved instantly when they are in position to receive impulse.

The mode in which impulse is imparted is a general source of error. If we divide the arc of impulse—that is, the angle the balance passes through—into degrees or minutes, the perfect impulse would be that which would vary in direction with every minute, and would constantly represent the tangent to the radius of contact, and in proportion as it deviates from this it causes more or less error by resistance of rubbing-surface.

With these general outlines of the escapement, which are to be filled in more by-and-by, we will pass on to trace its connection with the remaining part of the watch.

The wheel adjacent to and in connection with the escape-pinion* is the fourth or seconds-wheel, called so because its pinion carries the seconds-hand upon a long pivot extending through the dial, and turns about its own centre once every minute. The escape-wheel of modern watches has mostly fifteen teeth, each tooth giving two vibrations, or equivalent to two, which is equal to thirty vibrations, often called "beats" by watchmakers. A watch going at the rate of 18,000 vibrations per hour will make per minute $18,000 \div 60 = 300$, and rotations† of the escape-wheel $= 300 \div 30 = 10$ per minute; that is to say, the escape-wheel has to turn ten times on its own centre while the seconds or fourth wheel rotates once. This wheel being geared or pitched into the escape-pinion, in order to get this result the number of teeth in the wheel must be to the number of leaves in the pinion as the number of rotations of the escape-wheel is to that of the fourth wheel; that is, if we give the escape-pinion 7 leaves, and put the number of fourth or seconds teeth at x, then—

$$1 : 10 :: 7 : x,$$
$$x = 10 \times 7 = 70 = \text{the number of teeth.}$$

Going further back, we come to the relative rotations of the seconds or fourth and centre wheel, the former making sixty rotations to one of the latter. Between these two, which are connected by it, is the third wheel. Whatever number of teeth and leaves we give these wheels and pinions, in order that the seconds-wheel may rotate 60 times to 1 of the centre, their ratio must be such that the product of the centre and third wheel teeth is to the product of the third and seconds pinion leaves as 60 is to 1. If we give the third and fourth pinions eight leaves, the third wheel sixty, and centre wheel x, then—

$$1 : 60 :: (8 \times 8) : (60x);$$
$$60x = \frac{60 \times 64}{1} = 3840.$$
$$\therefore\ x = \frac{3840}{60} = 64 = \text{number of centre wheel teeth.}$$

This brings us to the last section of the train of watch-wheels.

Watches are generally designed to go from twenty-eight to thirty-two hours at one winding. For our illustration we will take a case at thirty-two hours, allowing six to eight hours surplus should the winding of the watch, through any occurrence, be delayed. The fusee, or toothed barrel, technically called the going-barrel, has therefore to turn the wheel adjacent to the centre wheel thirty-two times about its centre.

The fusee or going-barrel is, with very few exceptions, made to make four rotations to one winding, or thirty-two hours, and the centre wheel has therefore to make eight rotations to one of the fusee. The conditions of number of the respective wheels and pinions is therefore a mere repetition of the first one given; that is, the number of teeth of the driving-wheel is to the number of leaves in the pinion as the number of the rotations of the centre wheel is to that of the driving-wheel; or taking the centre pinion at 10 and driving-wheel at x, then—

$$1 : 8 :: 10 : x;$$
$$x = 10 \times 8 = 80 = \text{number of teeth in driving-wheel.}$$

Hence the watch goes eight hours for each turn of the fusee, or thirty-two hours at one winding.

Reviewing the whole, we notice four distinct cardinal sections—viz., the balance, escapement, train, and mainspring. Of these the first is the prime mover, the second a reservoir of impulsive force, the third the channel of supply, and the fourth the source of force. As it is desirable to have the impulse dealt out to the balance with as little perturbance as possible, it follows that the motive force should be transmitted to the escapement as regularly as possible; or, in other words, the force generated in the mainspring should be so economised that approximately the centrifugal force of the fusee may be to that of the escape-wheel as the velocity of the latter to that of the former, such economy depending on the watch being constructed in such a manner that no force is expended in overcoming undue resistance by erroneous contact. As such errors arise through imperfect gearing or pitching, we will add a few words on this subject.

By gearing, pitching, or a depth, is meant the relative position of a wheel and pinion in such a manner that all motion imparted to one wheel will communicate itself to the other in an inverse ratio to the number of their respective teeth. Supposing we place a wheel and pinion into the depthing tool, with sixty-four teeth and eight leaves respectively, the latter will make eight rotations to one of the first. If we now replace them by two discs in such a manner that they touch at their circumference, and communicate motion in the same ratio as the wheel and pinion so replaced, we shall find that when this condition of their motion is obtained their diameters are in the same ratio as the number of the teeth and leaves of the pinion. Such contact may be sufficient to communicate motion, but there is no certainty, neither is it possible to transmit force; hence the contrivance by which such two discs shall rotate in ratio to their diameters.

This contrivance consists in projections and recesses in both discs, so as to dip alternately into one another. The projections are in addition to the circle of the same diameter as the disc, which is called the primitive or pitch-circle, and the indentures, recesses, or spaces are in subtraction of the circle of the diameter of the disc, or within the pitch-circle. We have, therefore, a pitch-circle in every wheel and pinion, and these circles of a wheel and pinion forming a depth should be in exact ratio of their respective numbers, and in relation as the discs described.

The shape of the sides of such wheel-toothing is, or should be, formed by sections of the epicycloid, the curve being traced from either side of the tooth, the point of bisection being the termination of the toothing. (See "Technical Drawing," Vol. II., page 12.) The same can also be accomplished by co-ordinates. These methods and their elucidation belong to the

* A pinion is a piece of steel the circumference of which is regularly divided, and indentures cut into it to two-thirds of the radius from circumference, leaving six, eight, ten, or more projections called "leaves."

† There is considerable misconception about the terms *rotation* and *revolution*. The first means a wheel turning about its own centre, and the second about a borrowed centre. So, in the tourbillon, the escape-wheel rotates about its pivots, but revolves about the pivots of the tourbillon. Again, the earth rotates about its axis, but revolves around the sun.

province of the mathematician, and are beyond the limits of these papers. But in order that the practical workman, who may peruse these pages, may gather some idea of the epicycloidal curve, I suggest the following experiment in solid material:—Take a brass disc, describe a circle, which is to represent the pitch-circle, and mark off the breadth of a tooth. Prepare two discs, one the size of the circle described and fixed to it, and the other approximating on the ratio of a pinion of six, and fix a fine point in the circumference of the latter. Place them in the depthing tool in the following manner:—Let the discs touch one another, so as to communicate motion; let the point in the circumference and the side of the tooth be in a straight line between and parallel to the centre of the depthing tool, and let the point in the disc touch the wheel upon which the curve is to be traced. Moving now both discs together, a curve will be traced, which is a section of the epicycloid. If the same operation is repeated and reversed from the opposite side of the tooth, the epicycloidal toothing is traced out.

Be this curve mechanically or mathematically traced out, the condition of the toothing depends upon the ratio of the generating and primitive circles, for, as their difference diminishes, the altitude or height of the toothing traced increases. Considering the heterogeneous conditions of depths with various numbered pinions, we come upon the question: What is the proper or best ratio between the primitive and generating circles to obtain curves approximately suited to these various conditions? This, of course, cannot be discussed here, nor the question of contriving the production of a tooth in solid material answering in any number of repetitions to its duplicate. It must suffice to hint at one or two facts arising out of these conditions.

Going back for a moment to the discs or primitive circles for an illustration, and drawing a line from the centre of one to the centre of the other, which line is called the line of centres, we find that this line bisects or cuts the two circles in the point or place where they touch each other, and that at either side of this line the circles recede progressively from each other.

Consider a pinion of six leaves in the light of a circle, that circle being divided into six equal parts, the angle formed by the faces of two leaves is equal to 60°.

If we now measure off on our smaller circle an angle of 60° with the line of centres, and draw a line from the point thus measured off to the centre, the line thus drawn and the line of centres will represent the faces of two leaves of a pinion of six; and supposing that the contact of a tooth of the wheel and a leaf of the pinion commences in or at the line of centres, with a pinion of six leaves, such contact having to continue through a movement of 60°, we have further the altitude or height of the toothing indicated by the distance of the point measured off in the minor circle from the major circle. In a wheel and pinion the motion is communicated from the former to the latter by contact of the face of a leaf with the tooth, the latter pushing the other before it, until, by reason of the rotary and receding motion of the face of the pinion, the contact ceases, such cessation depending entirely, whether it be at an angle of more or less than 60°, on the altitude or height of the tooth; from which we gather that, as the pinion movement must be at a fixed angle of 60°, just as much as the contact of tooth and leaf passes through an angle of more or less than 60° past the line of centres, so also must the contact commence before or after the line of centres. Here we come upon the question as to how far it is practicable that the action should commence before the line of centres, the discussion of which must also be left, with the exception of one or two points.

The greatest amount of centrifugal force is communicated to a pinion by contact past the line of centre, when the former forms a maximum angle with the latter, because they assume the conditions of levers and inclined planes. On the other hand, if the contact takes place considerably before the line of centres, the whole force of the wheel is expended in pressure; hence all rotary motion ceases, and consequently the watch stops. In fact, in ninety-nine cases out of one hundred where a watch stops in a depth, it is because of the action commencing too soon. We have, therefore, two extreme limits of the greatest and least force transmitted, and in proportion as the action or contact takes place between these points we have economy or waste of mainspring power.

If a pinion is applied larger than the described ratio, the result is that the chord of two leaves of the pinion is greater than one of two teeth of the wheel; and hence, in such a depth, we get action before the line of centres, which, in proportion, will cause a stopping of the watch or some other irregularity. On the other hand, no small-sized pinion, provided the depth is not too shallow and that there is sufficient clearing, will ever cause a stoppage, because the action cannot commence before the line of centres.

In planting a depth it is necessary to ascertain the proper proportion of the wheel and pinion to be geared, because when the pinion is larger or smaller than it ought to be, it falls within or without the pitch-circle of the wheel, as the case may be. For example, if we have a standard depth with a pinion of the right size, and another of a wheel of the same size and number but a larger pinion, the last depth would require to be just as much deeper than the former as the half diameter of its pinion is greater than the other pinion.

The general way to ascertain the size of a pinion is by a sector, but as the counting of teeth and putting in the sector involves much time, I will give here a simple but correct method—namely, count the number of leaves in the pinion to be tried, add 2, and divide by 3, the quotient being the chord of the number of teeth (and, as a consequence, the spaces within them) that the diameter of a right-sized pinion measures.

Example.—In a pinion of seven we have $7 + 2 \div 3 = 3$, or equal to the space occupied by three teeth (and two spaces within), the measure of the diameter of a pinion of seven.

Again, for a pinion of ten, we have $10 + 2 \div 3 = 4$, or equal to the space occupied by four teeth (and three spaces within), the measurement of the diameter of a pinion of ten leaves. In this method it is assumed that the teeth and the spaces are equal; hence, where they are not, allowances must be made.

It will scarcely be necessary to observe that pivots should be as small as stability will permit, and as well glossed as possible, because the amount of resistance from or in the pivots is measured by the product of rubbing-surface and its radius; hence thick and rough pivots offer greater resistance than smooth and thin ones.

We gather, therefore, from the foregoing remarks that the balance requires a certain amount of impulse-force, which must be supplied to overcome the local resistance; that each wheel must give off to the preceding wheel as much force as that one again has to supply to the next, *plus* the force to overcome its resistance both of pivots and depth; and hence, in proportion as force is absorbed in its transmission through the train to overcome local resistance, so is there an excess of mainspring power required; and as, mechanically, no force is absolutely lost, this excess of force is working the destruction of the instrument. According to this, common and badly constructed watches require stronger mainsprings than good ones, and hence more frequent repairing.

Horological construction means, therefore, the formation of parts and their relative adjustment according to laws that govern them, so that all forces involved act harmoniously toward one and the same end.

The principle of construction is, therefore, not exhausted until the last piece of a watch has been described, and hence what has been said is more to be accepted as a view of the whole. A spectator standing on a hill surveying a landscape, will have an idea of the relation of each single object to the whole when he comes to examine it separately. In the same sense, I hope I have succeeded in making clear to the reader the relative office of these sections to the correct record of the hands on the dial of his watch.

THE LATHE.—XVI.

By Henry Northcott.

LATHES FOR SPECIAL PURPOSES.

The self-acting lathes hitherto given are such as are in general and universal use for the miscellaneous work of engineering workshops. Either of these lathes is capable of producing a great variety of forms, from a small bolt to an excentric, and in every workshop there is enough miscellaneous work to keep one or more of these lathes employed upon it. But when a large number of bolts or excentrics have to be produced—enough to

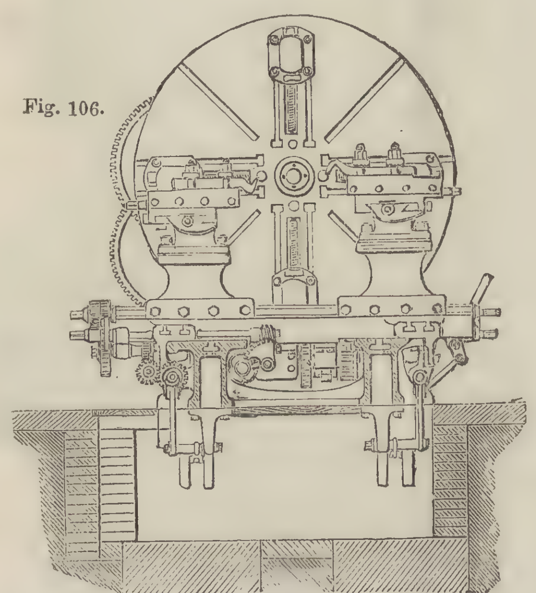
keep a lathe going—it becomes advisable to have a lathe designed especially for the production of that one article, without reference to its general usefulness. The precise form the special lathe will take depends, of course, upon the motions it is called upon to execute. In some cases the ordinary lathe may need very little, if any, modification beyond the use of tools of a certain shape, and in other cases the lathe mechanism may require to be of a very complicated and peculiar nature. Frequently the chief alteration necessary is in the size. Massive work requires a massive lathe, but very large lathes are seldom made on the same model as those of moderate size. Figs. 104 to 109 illustrate a large lathe made by Messrs. Ducommun and Co., of Mulhouse, and exhibited at the last Paris Exhibition. Of the illustrations, Fig. 104 is a longitudinal elevation; Fig. 105 a plan; Fig. 106 a cross section showing the slide, toolrests, and face-plate; Fig. 107 is an end elevation of the cone headstock; Fig. 108 an end elevation of the screw headstock; and Fig. 109 a cross section showing the saddle-rest.

This lathe, for the description of which I am indebted to *Engineering*, is designed for turning heavy marine work and heavy guns, and it has sliding and screw-cutting mechanism, with other; the reverse motion of the screw for cutting left-hand threads may be obtained by causing one or other of these pinions to gear into the first of the train of wheels that drive the screw with a slight motion of the lever only, and without the necessity of introducing an intermediate pinion, which has to be removed again. The propriety of fitting a heavy lathe like this with a screw-cutting motion might with some show of reason be called into question, but the screw was introduced chiefly to meet the condition of turning true conical surfaces, a condition imposed upon the maker by the officials in command of the French arsenals.

The longitudinal sliding motion is derived directly from the screw in much the same manner as in smaller lathes, and the slide-rest may be moved by hand along the bed, through a pinion gearing into a rack fixed to the under-side of the top table of the lathe-bed, in which case the nut is disengaged from the screw by means of a worm and worm-quadrant working a system of small levers.

The slide-rest carries two cross slides, each worked by an independent screw, by means of which arrangement two cuts may be taken simultaneously at opposite sides of the work. These

Fig. 106.



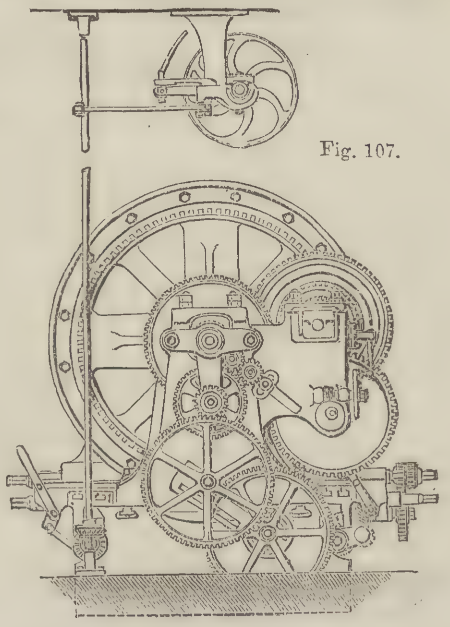
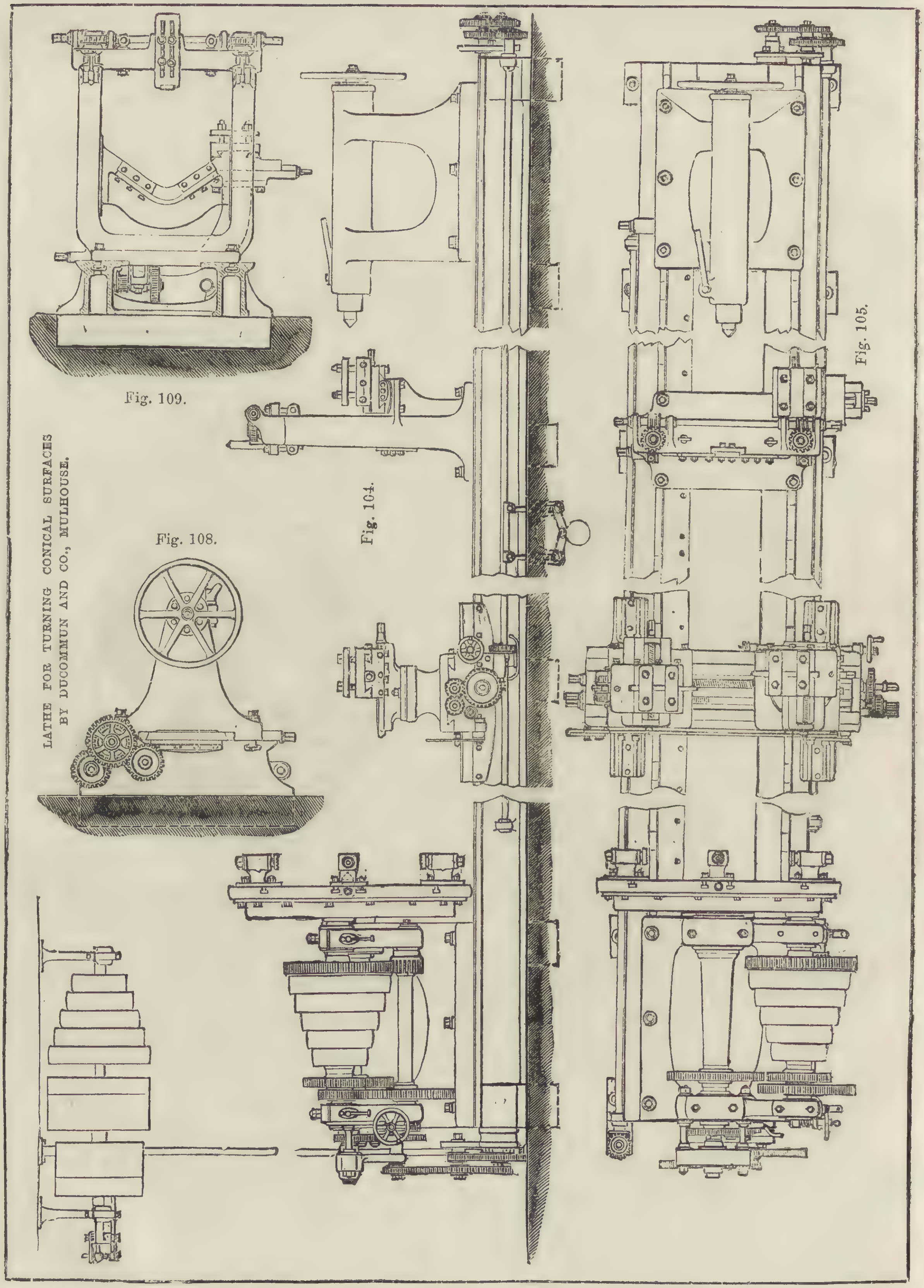


Fig. 107.

an arrangement for producing true conical surfaces. The lathe-bed, which is cast on the box principle, is about 40 feet long, and 5 feet wide, measured over the V's; the height of the centres is about 3 feet 6 inches, thus admitting an article of about 7 feet diameter. The fixed or cone headstock is double-geared, provided with an internally geared face-plate, and quick return motion direct through the lathe-spindle. The cone-shaft, whose bearings are made to slide horizontally towards and from the centre of the lathe-bed, may be thrown out of gear with the face-plate by means of two set-screws; at the same time a small pinion which it carries is thrown into gear with the wheel on the main spindle, when it is intended to run at quick speed. The intermediate shaft, through which motion is communicated to the face-plate when taking heavy cuts, revolves in excentric bearings, and is thrown out of gear by turning these bearings round upon their own centre by means of a worm and worm-wheel. The tendency of this shaft being to fall back into the position of greatest stability, the worm-wheel should be provided with some kind of stop, to prevent the shaft from being thrown out of gear by the jar of the wheels in motion.

The main spindle rests in cylindrical bearings, and is fitted with a thrust-pin behind, in preference to the conical bearings so largely used in this country. The screwing motion is derived from the lathe-spindle in the ordinary manner, but by means of a very neat arrangement of a lever pivoting upon a stud, and carrying permanently two equal pinions which gear into each cross slides are also moved indirectly by the main screw, through a train of wheels, the first of which is fixed to the end of the former, where it projects through the lathe-bed. Motion is thus given to a shaft which carries a sliding wheel, which drives a worm and worm-wheel, and by means of a small spur-wheel which gears into one of the small pinions carried by the screws of the cross slides, these slides are moved simultaneously either towards or away from the centre of the lathe-bed, as may be necessary.

It is by means of this arrangement that the lathe is made to turn strictly accurate conical surfaces; and by reversing the motion of the main screw, by the arrangement of wheels just described, the lathe may be made to work both backwards and forwards, whether the surface being turned be cylindrical or conical; while by changing the ratio of the wheels through which the cross slides derive their transverse motion, the degree of taper to be given to the cones may be varied and adjusted at will. It was this desideratum of turning a true conic shaft that necessitated the adoption of a screw for working the main slide, and to the necessity of obtaining the transverse motions of the cross slides from the main screw, instead of adopting the more common method used in slide-lathes of working the main slide by rack and pinion from the main spindle, direct by a belt running upon small cones, because the forward motion obtained by the rack is less uniform than that obtained from a screw, and any slip of a belt would destroy the synchronism of the



LATHE FOR TURNING CONICAL SURFACES BY DUCOMMUN AND CO., MULHOUSE.

Fig. 104. Fig. 105. Fig. 108. Fig. 109.

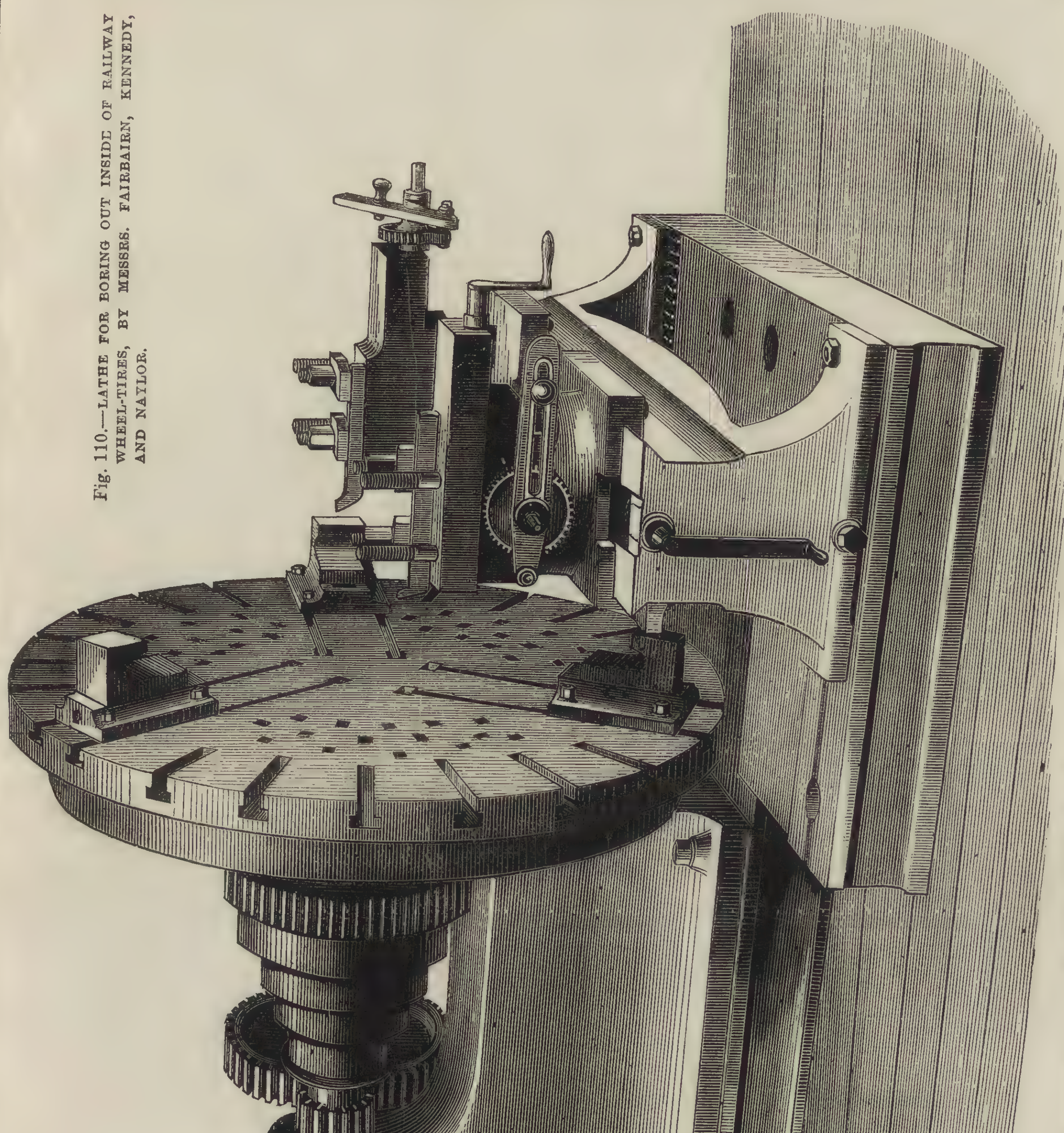


Fig. 110.—LATHE FOR BORING OUT INSIDE OF RAILWAY WHEEL-TIRES, BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

motions of the several slides, with the circumferential speed of the piece of work to be turned.

This lathe is also provided with a saddle-support, in which the work being turned is held in position by three adjustable guiding edges, the saddle proper being raised or lowered by means of a couple of worms, worm-wheels, and screws. The whole apparatus may be moved along the bed by a pinion gearing into the rack. A small compound slide-rest is also fixed on the saddle-support, in addition to the usual slide-rest, for the purpose of facing or shaping the end of the piece of work in the lathe.

The screw headstock, as will be seen, is of the usual construction, but being heavy, a handle with pinion gearing into the rack is attached to it for moving the headstock along the lathe-bed.

The reversing and stop motion of the overhead apparatus may be worked from the slide-rest in all its positions on the lathe-bed, by means of a system of levers and rods, which communicates an angular motion to a horizontal shaft, and this through a pair of bevel wheels to a vertical shaft. A lever which is keyed upon this works a sliding-rod fitted with forks, and these embrace the belts, and when moved, shift them from the fast to the loose pulleys, or the reverse.

Messrs. Ducommun and Co's. lathe, it will be observed, is a lathe on a very large scale, and complicated with mechanism for producing certain combinations of motions not required for ordinary work. Ordinary plain turning can, of course, be performed in such a lathe, as it is not even designed for the production of conical objects only. In the lathe shown at Fig. 110 the specialty is more apparent, as it is designed to effect one object only—namely, to turn or bore out the insides of railway wheel-tires preparatory to their being shrunk in upon the wheel proper. This lathe, which is by Messrs. Fairbairn and Co., consists of an ordinary heavy cone headstock with gearing, and having a very large face-plate upon its spindle-nose. The face-plate is fitted with adjustable gripping jaws, which may be moved either nearer to or farther from the centre of the lathe, according as a smaller or a larger tire has to be chucked. The flange of the tires falls into the undercut grooves of the jaws, whilst the tread is gripped by the three projections. All the other parts of this lathe are arranged altogether different from any yet illustrated. There is no screw headstock, and no substitute for it. The lathe-bed is merely a flat, short plate, and the slide for the two rests is at right angles to its usual position. The two slide-rests, in fact, are carried upon a short bed, which is fastened down upon the main bed-plate, across the front of the face-plate. The small transverse bed can be moved a short way upon the bed-plate, so as to alter its distance from the face-plate, but its parallelism with the face-plate is maintained. The slide formed by the bed is chiefly for the adjustment of the slide-rests in relation to their work, the traverse of the tools being effected through the slides of the rests proper, and by means of a ratchet-wheel and lever. Although this lathe is designed for producing a special article of which large numbers are required, it is almost equally well adapted to a great deal of other work of somewhat similar nature, and lathes differing but very little from this one are employed to turn up large plane surfaces such as the cylinder covers of horizontal steam-engines and other work.

The publishers of The Technical Educator feel it to be a duty as well as a pleasure to express their acknowledgments of the courtesy and kindness of the proprietors of *Engineering* in permitting them to reproduce the illustrations of Messrs. Ducommun and Co.'s lathe for turning conical surfaces.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVII.—DISCOVERIES OF SIR HUMPHREY DAVY.

(*Continued from Page* 314.)

Davy, for the investigation of the effects of nitrous oxide, devised the method of procuring the nitrous air—viz., the decomposition by heat of the crystals of nitrate of ammonia, which are thereby dissolved into watery vapour and the desiderated gas. Under the famous name of nitrous oxide, he minutely examined and recorded its properties for the first time. In his "Researches," he tells us: "Having previously closed my nostrils and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to giddiness; but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by a highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, and at last an irresistible propensity was indulged in. I recollect but indistinctly what followed; I know that my motions were various and violent. These efforts very soon ceased after respiration; in ten minutes I had recovered my natural state of mind. Almost every one who has breathed this gas has observed the same thing. On some few, indeed, it has no effect whatever, and on others the effects are always painful. The experiment cannot be made with impunity by those who are liable to determination of blood to the head."

Davy was at first sanguine of the useful application of nitrous oxide to medicine. It might be the notable gold of Geber, the vivifying quintessence of the elements of Raymond Lully, the water of life of Basil Valentine, the elixir of Paracelsus—at least some purified and attempered supporter of vitality, for its composition was almost identical in its ingredients with that of the atmosphere. But Davy soon discovered his mistake, recorded its inutility, and pointed out the fallacies attendant on the trial of so strange and novel a medicinal agent. Nevertheless, in describing its effects, Davy predicted that as "nitrous oxide, in its extension, seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." (Davy's "Collective Works," Vol. III.) Nor was this an accidental conjecture of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea, which by chloroform has become one of the most glorious realities of the present century. Davy also foretold that pneumatic chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded, "it is probable that pain would have been put into subjection to the intellect at the very beginning of this century." In 1818, in a paper in the *Quarterly Journal of Science and Art*, believed to have been written by Mr. Faraday, is described the great resemblance between the effects of ether and those of nitrous oxide gas. Dr. Bigelow, of Boston, U.S., also predicted nitrous oxide to be quite likely to prove a certain as well as a safe and agreeable anæsthetic agent.

In 1801 Davy came to London, and on the 25th of April he gave his first lecture at the Royal Institution. He began with the history of galvanism—Sir Joseph Banks, Count Rumford, and other distinguished philosophers being present; he detailed the successive discoveries, and described the different modes of accumulating it. On the 31st of May, 1802, he was appointed Professor. From the year 1800 to 1807, a great variety of subjects attracted his attention, especially galvanism and electro-chemical science; the examination of astringent vegetable matter in connection with the art of tanning, and the analysis of rocks and minerals with relation to geology and agricultural chemistry. In November, 1807, his second Bakerian lecture was read, in which he announced the most important and unexpected discovery of the decomposition of the fixed alkalies by galvanism, and of the metallic nature of their bases, to which he gave the name of potassium and sodium. Dr. Paris has well observed that "since the account given by Newton of his first discoveries in optics, it may be questioned whether so happy and successful an instance of philosophical induction has ever been afforded as that by which Davy discovered the composition of the fixed alkalies." In the basement of the Royal Institution, "the workshop of the Royal Society," was fitted up the vast apparatus with which Davy made the above discovery. The battery was of immense power, and consisted of 2,000 separate parts, each composed of ten double plates, and each plate containing 32 square inches; the number of double plates being 2,000, and the whole surface 128,000 square inches. This vast battery, of magnitude and completeness not before attempted in this country, has long been destroyed. It is related of the ludicrous indolence of a worthy professor of chemistry at Aberdeen, that he had allowed some years to pass over Davy's brilliant discovery of potassium and its congeneric metals with-

out a word about them in his lectures. At length the learned doctor, being pressed by some of his colleagues on the subject, condescended to notice it. "Both potash and soda," said he, "are now allowed to be metallic oxides; the oxides, in fact, of two metals, called potassium and sodium by the discoverer of them, one Davy in London, *a verra troublesome person in chemistry.*"

Davy's lectures were often attended by 1,000 persons; his youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations, and well-conducted experiments, and the auspicious state of science, ensured Davy instant success. The enthusiastic admiration with which he was hailed can hardly be imagined now. Not only men of the highest rank, men of science, men of letters, and men of trade, but women of fashion and blue stockings, old and young, pressed into the theatre of the Royal Institution to shower on him their applause.

From the year 1808 to 1814, important papers were read by Davy to the Royal Society, which are thus referred to by his brother and biographer, giving a sketch of the most important facts and discoveries which they contain, referring the chemical reader to the original for satisfaction. "After the extraction of the metallic bases from the fixed alkalies," says Dr. Davy, "analogies of the strongest kind indicated that the alkaline earths are similarly constituted; and he succeeded in proving this in a satisfactory manner. But owing to various circumstances of peculiar properties, he was not able, on his first attempt, to obtain the metals of those earths in a tolerably pure and insulated state for the purpose of examination. On his return to the laboratory after his illness, this was one of his first undertakings. He accomplished it to a certain extent by uniting a process of MM. Berzelius and Pontin, who were then engaged in the same inquiry, with one of his own. By negatively electrifying the earths, slightly moistened, and mixed with red oxide of mercury, in contact with a globule of mercury, he obtained amalgams of their metallic bases; and by distillation with peculiar precautions, he expelled the greater part of the mercury. Even now, in consequence of the very minute quantities of the bases which he procured, he was only able to ascertain a few of their properties in a hasty manner. They were of a silvery lustre, solid at ordinary temperatures, fixed at a red heat, and heavier than water. At a high temperature they abstracted oxygen from the glass, and at ordinary temperatures from the atmosphere and water, the latter of which they, in consequence, decomposed. The names he proposed for them, and by which they have since been called, were barium, strontium, calcium, and magnium, which he afterwards altered to magnesium.

"The same analogies were nearly as strongly applied to the proper earths; and he attempted their decomposition, but not with the same success.

"The application of these facts to geology was full of promise; and he indulged in the hope that they might serve to explain not only some of the most mysterious phenomena of nature, as earthquakes and volcanoes, and the combustion of meteoric stones and falling stars, but might ultimately lead to a general hypothesis of the formation of the crust of the earth." His ideas on this last subject Davy afterwards, in some measure, relinquished.

After effecting the decomposition of the fixed alkalies, Davy, reasoning from analogy, conjectured that ammonia might also contain oxygen; but his first experiments contained a fallacy. In his various papers on oxymuriatic acid and its compounds, he established the views of Scheele respecting its nature, and showed that the reasoning of Berthollet, which had generally been admitted by chemists, proved fallacious. He shows that oxymuriatic acid is not a compound, as supposed, of muriatic acid and oxygen, but an undecomposed body, to which, on account of its green colour, he gave the name of chlorine. In 1810 he published his "Elements of Chemical Philosophy," of which only the first volume was printed. His "Elements of Agricultural Chemistry," which appeared soon after, contains much useful matter, and is replete with sound and practical views on the subject.

Davy's best known achievement was his invention of the miner's safety lamp. The properties of fire-damp in coal mines had already been ascertained by Dr. Henry. When this gas is mingled in certain proportions with atmospheric air, it forms a mixture which kindles upon the contact of a lighted candle, and explodes with the violence of a tremendous piece of artillery. Such a detonation occurred within a coal mine in the north of England, so dreadful that it destroyed more than 100 miners. Davy was implored to provide a method of preventing such awful visitations; and he did it. Having conceived that flame and explosion may be regulated and arrested, he ascertained that explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at the same time, and likewise diminishing their length and increasing their number, so that a great number of small apertures would not pass explosion when their depth was equal to their diameter. This fact led to trials upon sieves of wire-gauze. It was found that if a piece of wire-gauze was held over the flame of a lamp, or coal-gas, it prevented the flame from passing; and he ascertained that a flame confined in a cylinder of very fine wire-gauze did not explode even in a mixture of oxygen and hydrogen, but that the gases burnt in it with great vivacity.

These experiments served as the basis of the safety lamp. The apertures in the gauze, Davy tells us in his work on the subject, should not be more than $\frac{1}{22}$nd of an inch square. The lamp is screwed on to the bottom of the wire-gauze cylinder, and fitted by a tight ring. When it is lighted, and gradually introduced into an atmosphere mixed with fire-damp, the size and length of the flame are first increased. When the inflammable gas forms as much as $\frac{1}{12}$th of the volume of air, the cylinder becomes filled with a feeble blue flame, within which the flame of the wick burns brightly; its light continues till the fire-damp increases to $\frac{1}{6}$ or $\frac{1}{5}$, when it is lost in the flame of the fire-damp, which now fills the cylinder with a pretty strong light; but when the foul air constitutes $\frac{1}{3}$ of the atmosphere, it is no longer fit for respiration, and this ought to be a signal to the miner to leave that part of the workings. Davy first communicated the discovery of the safety lamp to the Royal Society in 1815; on January 11, 1816, he announced the principle of the lamp, a model of which, made by his own hands, he presented to the Royal Society, and it is preserved in their collection at Burlington House. The merit of the discovery was claimed by George Stephenson; but the question was set at rest in 1817, by an examination, attested by Sir Joseph Banks, P.R.S., Mr. Brande, Mr. Hatchett, and Dr. Wollaston, who awarded the independent merit to Davy, not only in point of date, but as regards the long chain of inductive reasoning concerning the nature of the flame by which the result was arrived at. "I value it," remarked Davy, with the kindliest exultation, "more than anything I ever did; it was the result of a great deal of investigation and labour; but if my directions be attended to, it will save the lives of thousands of poor men."

The principle of the invention was this. In the safety lamp, the mixture of the fire-damp and atmospheric air within the cage of wire-gauze explodes upon coming in contact with the flame; but the combination cannot pass through the wire-gauze, and being there imprisoned, cannot impart to the explosive atmosphere of the mine any of its force. The effect has been attributed to the cooling influence of the metal; but since the wires may be brought to a degree of heat but little below redness without igniting the fire-damp, this does not appear to be the cause. The invention has been characterised as *the shutting up in a net of the most slender texture* of a most violent and irresistible force, and a power that in its tremendous effects seems to emulate the lightning and the earthquake.

Sir Humphry devoted much time to examining the state of the Herculaneum manuscripts, and illustrating chemical arts of the ancients. He analysed the colours used in painting by the ancient Greek and Roman artists. His experiments were chiefly made on the paintings in the baths of Titus, the ruins called the Baths of Livia, in the remains of other palaces and baths of ancient Rome, and in the ruins of Pompeii. By the kindness of his friend Canova, who was charged with the works of ancient art in Rome, he was able to select with his own hands specimens of the different pigments that had been found on vases discovered in the excavations which had been lately made beneath the ruins of the palace of Titus, and to compare them with the colours on the walls, or on fragments of stucco. The results of all these researches were published in the *Transactions of the Royal Society* for 1815, and are extremely inte-

resting. The concluding observations, in which he impressed on artists the superior importance of permanency to brilliancy of colours used in painting, are especially worthy of the attention of painters. On his examination of the Herculaneum manuscripts at Naples, 1818-19, he was of opinion that they had not been acted upon by fire so as to be completely carbonised, but that their leaves were cemented together by a substance formed during the fermentation and chemical change of age. He invented a composition for the solution of this substance, but he could not discover more than 100 out of 1,265 manuscripts which presented any probability of success.

In 1819-20, during a residence at Naples, Davy made a series of investigations of Vesuvius, bearing upon a previous hypothesis, that "metals of the alkalies and earths might exist in the interior of the globe, and on being exposed to the action of air and water, give rise to volcanic fires, and to the production of lava, by the slow cooling of which basaltic and other crystalline rocks might subsequently be formed." We give an abstract of the result of Sir Humphry's observations. "The phenomena observed by the author afforded a sufficient refutation of all the ancient hypotheses, in which volcanic fires were ascribed to such chemical causes as the combustion of mineral coal, or the action of sulphur upon iron, and are perfectly consistent with the supposition of their depending upon the oxidation of the metals of the earths upon an extensive scale, in immense subterranean cavities, to which atmospheric air may occasionally have access. The subterranean thunder heard at great distances under Vesuvius, prior to an eruption, indicates the vast extent of these cavities; and the existence of a subterranean communication between the Solfaterra and Vesuvius, is attested by the fact that whenever the latter is in an active state, the former is comparatively tranquil. In confirmation of these views, the author remarks, that almost all the volcanoes of considerable magnitude in the Old World are in the vicinity of the sea; and in those where the sea is more distant, as in the volcanoes of South America, the water may be supplied from great subterranean lakes; for Humboldt states, that some of them throw up quantities of fish. The author acknowledges, however, that the hypothesis of the nucleus of the globe being composed of matter liquified by heat, offers a still more simple solution of the phenomena of volcanic fires."

Among the honours awarded to Davy were the Copley, Royal and Rumford medals from the Royal Society; he several times received the Bakerian prize; and Napoleon's prize for the advancement of galvanic researches from the French Institute. The coal-owners of the Wear and Tyne presented Davy with a dinner service of silver, worth £2,500. In 1818, at the age of forty, he was created a baronet.

Sir Humphry became President of the Royal Society in 1820, and he continued to contribute papers of great interest for some years. Among the most curious of these, and full of promise as to utility, were those which related to the modes of protecting the copper sheathing of ships; to this subject Sir Humphry gave much of his time, and personally inspected all the boats and vessels on which the trials were made. Although the theory on which they were conducted proved eminently correct, no advantage could be ultimately taken of the plan which it suggested. The saving of the copper was wholly counterbalanced by an accumulation of shell-fish and sea-weed on the sheathing, which became sufficient, in a short time, to prevent the proper command of the ship at the helm. He resigned the presidency of the Royal Society in 1827, after which he retired to Geneva, where he died May 28, 1829. "His public service of plate, his imperial vases, his foreign prizes, his royal medals, shall be handed down to his collateral posterity as trophies won from the depths of nescience; but his *work*, designated by his own genius, executed by his own hand, tracery and all, and every single stone signalised by his own private mark, indelible, characteristic, and inimitable; his *work* is the only record of his name. How deeply are its foundations rooted in space, and how lasting its materials for time."—*North British Review*, No. 3.

In 1827 the Royal Medal was awarded by the Royal Society to Sir Humphry for his brilliant discoveries developing the relation between electricity and chemistry, when Mr. Davies Gilbert, the president, said: "Having witnessed the whole progress of Sir Humphry's advancement in science and reputation, from his first attempts in his native town to vary some of Dr. Priestley's experiments on the extraction of oxygen from marine vegetables, to the point of eminence which we all know him to have reached, it is not necessary for me more than to advert to his discovery of nitrous oxide, to his investigation of the action of light on gases; of the nature of heat; to his successful discrimination of proximate vegetable elements; nor to his most scientific, ingenious, and useful invention, the safety lamp, an invention reasoned out from its principles, with all the accuracy and precision of mathematical deduction." Professor Playfair remarks: "This is exactly such a case as we should choose to place before Bacon, were he to revisit the earth, in order to give him, in a small compass, an idea of the advancement which Philosophy has made since the time when he pointed out to her the route she ought to pursue."

The remains of Sir Humphry Davy rest in the burial-ground at Geneva. In the procession which followed the corporate bodies and countrymen of the deceased, were many of the most eminent manufacturers of Geneva, and a large body of mechanics, who were anxious to pay this tribute of regard and gratitude to one whom they deservedly looked upon as a great benefactor to the arts, and promoter of science, by the application of which they earn their livelihood.

OPTICAL INSTRUMENTS.—XXVI.

BY SAMUEL HIGHLEY, F.G.S.

THE MAGIC LANTERN (*continued*).

Chromatic aberration is dependent on the unequal refrangibility of each of the coloured rays into which white light is decomposed on passing through the refractive substance of a lens. As the red rays of the spectrum are least, while the violet rays are most strongly refracted, it is evident that the violet rays, A, will be brought to a focus at a nearer point to the axis of a lens than the red rays T, as shown in Fig. 126. The

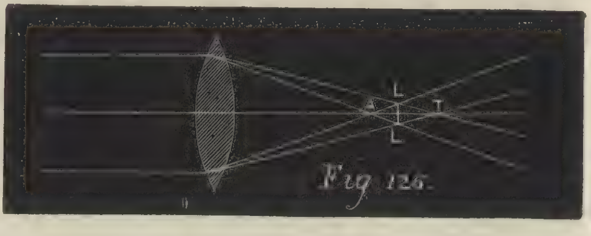


Fig. 126.

space between A and T constitutes the chromatic aberration; within it are situated at various points the foci of the intermediate rays of the spectrum, the focus of the yellow rays (*visual focus*) being shown at L, L, the point of intersection of the violet and red rays. As every tint in the spectrum ranging from violet to red has a distinct focal plane between the points A and T (Fig. 126), it results that a confused series of images will arise, which will have the effect of causing the images of objects to be fringed with the colours of the spectrum.

Chromatic aberration in a convergent lens of crown glass may be corrected by associating with it a divergent lens of flint glass of suitable curvature and dispersive power, the pair having one face common, B, B (Fig. 127), at which they are cemented together by Canada balsam. Then, if an incident ray of white light, W, falls on the face of the crown glass, C, the ray will be refracted

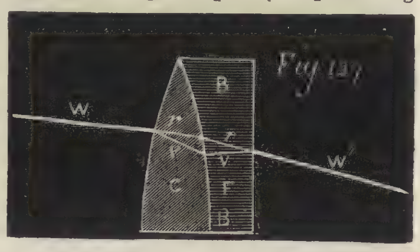


Fig. 127.

and split up by the dispersive power of the material, so that the violet ray will be bent towards *v*, and the red ray towards *r*; but on entering the flint-glass lens of opposite curvature, F, both the violet ray and the red ray will be refracted towards the plane face of the correcting lens, whereat all the

previously dispersed rays will be again re-united, and they will emerge as white light, W′.

It should be observed, however, that a lens which has been achromatised for incident rays parallel to its axis, will not prove achromatic for incident rays oblique to its axis. Again, as in the correction of spherical aberration, chromatic aberration may be under or over corrected. By varying the form of the lenses, and the happy combination of curves, in connection with a judicious selection of crown and flint glass of different refractive powers, the optician finds a wide latitude for constructing lenses corrected for spherical and chromatic aberrations, according to the purpose for which a lens is to be employed.

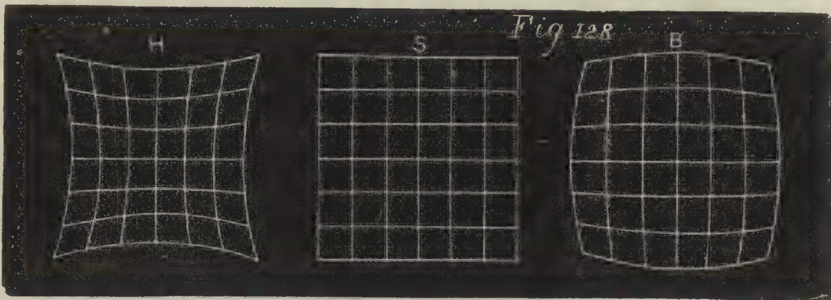


Fig 128

Refractive aberration, or in other words "distortion," is common to many lenses, producing images wherein straight lines are represented as bulged inwards or outwards. This defect has often been confounded with spherical aberration, whereas it is dependent on the media of the lenses refracting more strongly at the marginal than at the central part of the lens, consequently bending *outwards* those portions of a line which are nearest the margin, and producing a *pincushion* or *hour-glass shaped* image, H, of a square object, S, as in Fig. 128; or *inwards*, producing a *barrel-shaped* image, as at B (Fig. 128).

Such hour-glass or barrel-shaped distortion may also be produced according as we place a diaphragm before or behind the lens. The single combination as arranged in a magic lantern tends to produce the hour-glass kind of distortion. This may be corrected by painting all marginal lines in the slide *that ought to be straight*, as in architectural subjects, *curved* just to an extent that will balance the distortive aberration of the power, when the image of the distorted painting will appear architecturally correct. Such a device is well suited for correcting the shortcomings of large old-fashioned lanterns. In modern lanterns this defect may be overcome by employing a double or triple achromatic combination, when the source of light will admit of the same. Such distortions herein described are of serious consequence when lettered diagrams, architectural or any other subjects, including straight marginal lines, are to be depicted on the screen on which the image is shown.

Name of Material.	Density.	Index of Refraction.	Dispersive Power.
Crown glass, No. 1	2·48	1·50	0·039
Crown glass, No. 2	2·51	1·52	0·04
Light flint glass, No. 1 . . .	3·2	1·57	0·0473
Heavy flint glass, No. 2 . . .	3·64	1·64	0·055
Very heavy flint glass, No. 3 . .	3·84	1·64	0·059

The preceding are the indices of refraction of the kinds of optical glass made by Chance of Birmingham, and which English opticians employ.

Single achromatic combinations may be of the following types:—(1.) The old-fashioned plano-convex, consisting of crown and flint, as shown in A (Fig. 129). (2.) The meniscus, wherein the concave face of flint glass is turned towards the object to be reproduced as a reduced image and in reversed position for an enlarged image, and the convex face of crown glass is turned towards the screen, as shown at B, known as the old Continental form. (3.) The meniscus known as the new or English form, being that adopted by Andrew Ross, and Grubb of Dublin, wherein the relative position of the crown and flint lenses are reversed, as shown at C, the concave face of crown glass being turned towards the object to be reproduced, and the convex face of flint glass being turned towards the screen, the object being to increase the focal length of the incident rays oblique to the axis, so as to give a very flat focal plane (see Fig. 125), and reduce the amount of spherical aberration to a greater extent than in the old single achromatic objective, to allow of a diaphragm of greater aperture being used, the focal length of the objective, in relation to the extent of image, being at the same time reduced.

The diameter of the old form is generally *the seventh* of its focal length, and if we were to treat it as a photographic lens, and receive the image of a landscape on the screen of a camera, the longer side of the image sharply defined would equal *half* its focal length. The *diameter* of the modern form is generally *the fifth* of its focal length, and the longest side of the image, treated as above, would equal two-thirds of its focal length. The old form has less distortion than the modern objective, taking as terms of comparison the size of the image; but it has more if we take for the term of comparison the focal length of the objective.

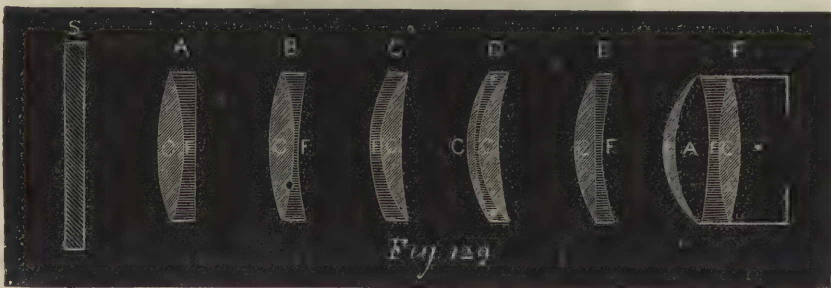


Fig 129

(4.) The "triple meniscus" of Dallmeyer, shown at D, which consists of a concavo-convex flint-glass lens enclosed between two concave meniscus lenses of crown glass having slightly different refractive indices, and focal lengths in the ratio of 1 to 3; the three are cemented together, the inner radii of curvature being equal. This combination gives a maximum of angle with a minimum of distortion, when properly stopped down, and the concave surface is turned towards the object to be reproduced as a reduced image, and in reversed position for an enlarged image. It covers with equal illumination a circular focal plane of 90°. The field of this objective is enormous, for the longest side of the image, treated as above, is greater than its focal length, the best form previously described yielding a

perfectly defined image but two-thirds of its focal length. Such a result is not to be attained by the employment of two lenses only, no matter how achromatised. This objective is admirably adapted for showing large pictures in small rooms, as an increase of angle of field is equivalent to a lens of shorter focal length with a proportionally larger aperture; but, unfortunately, the two cemented surfaces present a great drawback to its employment in combination with weak lights, such as the Argand burner, though this does not obtain when we are using the lime-light apparatus.

(5.) The "periscopic lens," wherein the radius of the concave face is less than that of the convex face, and consequently the concavity is greater than the convexity, as shown at E, which is constructed of a plano-concave flint cemented to a plano-convex crown lens. In this form the marginal rays are refracted to a greater extent than the axial to secure flatness of field. One of the first achromatic lenses of this character was made for the Rev. J. B. Reade by Andrew Ross, and in more recent years this form was sold by the late J. T. Goddard of Hounslow, an honoured name on the roll of inventive opticians.

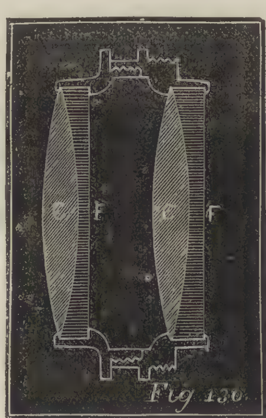


Fig. 130.

(6.) The "double periscopic" lens of Goddard, shown at F, of peculiar construction, so arranged, that when placed in a suitable position, oblique rays would be corrected. It consists of a double-convex crown cemented to a double-concave flint, the two neutralising each other in respect of magnifying power, the back element being a meniscus of deep curvature, neatly cemented by flatly-ground edges to the front combination, so as to enclose an air-cavity, A. The single achromatic usually supplied for lantern purposes are those figured at A and B (Fig. 129); but the other forms, employed in photography, are eminently suggestive for improvements in lantern construction, if we bear in mind that the coincidence of the chemical and visual foci, the *sine quâ non* of the photographer, which adds greatly to the cost of production, is not essential for ordinary lantern purposes.

The double achromatic lantern power consists of two achromatic plano-convex or two achromatic meniscus lenses arranged close together, as shown in Fig. 130. To work with condensers of $3\frac{1}{2}$ inches diameter, each combination is of 8 inches focus, forming a double combination of 4 inches focus. To work with 4-inch condensers, each element is of 9 inches focus, producing a combined focus of $4\frac{1}{2}$ inches. This is a very serviceable arrangement, for by unscrewing the back lens, and inserting "the lengthener," L (Fig. 121), it is immediately converted from a short to a long focussed combination: in the first case giving a flat field, imperceptibly free from distortion, unless sought for with hypercritical eyes; in the second case the same applies, as with the long focus there is less strain on the lens. This arrangement used as a double combination presents advantages over the next power described when used in a small room, for while with this lens we may reckon that for every foot on the screen we must pull back the lantern one foot, with a photographic portrait lens we must pull back eighteen inches and in some cases two feet; so that while with one power we should have to place the lantern 10 feet from the screen to get a 10-foot disc, with the other we should have to place it at 15 feet, and with the third 20 feet away, to get a 10-foot picture, while, as a rule, we could only get a range of 20 feet in a public institution, not a private residence.

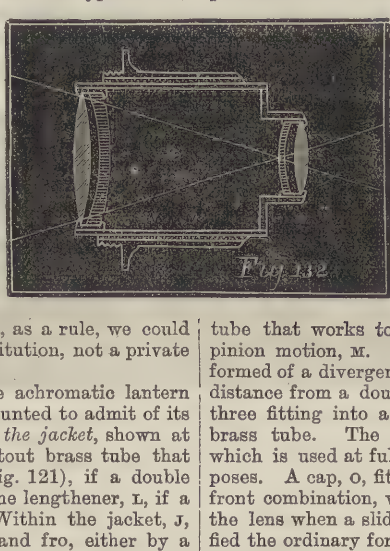


Fig. 132.

Having described the single and double achromatic lantern power, it is necessary to state how it is mounted to admit of its being attached to the lantern by means of *the jacket*, shown at J (Fig. 121). The jacket consists of a stout brass tube that screws directly into the front tube, T' (Fig. 121), if a double combination power is employed; or into the lengthener, L, if a single long-focussed power is required. Within the jacket, J, is a longer tube that can be worked to and fro, either by a sliding motion like a telescope tube (in which case the jacket should be lined with cloth, not only for the purpose of making the action freer, but for keeping the inner tube polished), or by means of a rack-and-pinion motion, M, fixed to jacket and inner tube. Into the end of the inner tube next to the lantern the power screws, the front end being finished by an ornamental casting. Within the inner tube, another is fitted that carries the diaphragm or stop, S. The diaphragm is, as a rule, a powerful agent in the hands of the optician: by decreasing its aperture, greater sharpness of the image is secured; by placing it in the best position near to the lens, spherical aberration may be reduced and distortion corrected, according to the nature of the shortcoming he most wishes to surmount; for, as I have already said, optics is a game of give and take, and the optician has constantly to "rob Peter to pay Paul;" but when using a stop for the magic lantern, it can hardly be said that it is employed as an optical element; for as we cannot afford to lose light by cutting off any of the marginal rays of the transmitted beam, it is really only used to shield the screen from that glare which is reflected from the marginal surface of the power, in a manner that detracts so much from the brilliancy of the enlarged picture, if the stop be removed.

The photographic portrait lens, of the size known as the quarter plate, with a focus of $4\frac{1}{2}$ inches, makes one of the best achromatic powers for the lantern if the operator is not confined for space. The short-focussed stereoscopic lens of the same construction is unsuited for this purpose, as it will not cover a 3-inch slide; while the *carte de visite* lens, likewise of the same type, is too long in focus for ordinary use, though it would be the very best arrangement, as the corrections are made with a view of including objects standing nearly in one plane. For exhibitions in theatres or halls of great length, the half-plate portrait lens, from its extra length of focus and greater diameter, serves the purpose to perfection, for though it may be said that a lens producing pictures on a flat screen *absolutely* free from distortion and curvature of field is next to an impossibility, the nearest approach to perfection is attained when the diameter of the lens equals that of the picture to be reproduced, and its focal length is long in proportion to its size, while the objects to be reproduced are situated in one plane, at right angles to the general axis of the lens. The most convenient half-plate lens for magic-lantern purposes at theatres, halls, etc., is that arranged by Derogy, as it is provided with extra lenses, by which the normal focus may be lengthened or shortened, so that it meets any requirements at a public exhibition as to distance between lantern and screen. In such cases the extra cost must not be permitted to be a matter of consideration.

The double portrait lens invented by Petzval may be said to be the direct antithesis to the wide-angle single combination, for while the latter embraces a large area when worked with a small stop, the former includes only a small angle of view with a large stop.

It consists of an achromatic meniscus (nearly plano-convex) crown and flint cemented front combination, F C (Fig. 131), the convex surface of which is turned towards the object to be reproduced when used for photographic purposes, and towards the screen when fixed in the lantern; this is set in a cell which screws into a tube that works to and fro in the jacket, J, by a rack-and-pinion motion, M. The back is a double-convex combination formed of a divergent meniscus of flint glass, F, kept at a certain distance from a double convex of crown glass, C, by a ring, the three fitting into a cell that screws into the other end of the brass tube. The position of the diaphragm is shown at S, which is used at full aperture when employed for lantern purposes. A cap, O, fits on to a metal shade that screws over the front combination, which is useful for covering and uncovering the lens when a slide is changed. Dr. Monckhoven has modified the ordinary form of Petzval's portrait lens for the special requirements of "photographic enlarging," in a manner that also meets the wants of the lantern exhibitor. He makes the

back combination just large enough to include neither more nor less than the entire cone of rays from the condenser when they are brought to a focus on the front combination, so that there shall be neither loss of light nor diffraction blurs (which would arise if the rays impinged on the metal mount), and the front only about half the diameter of the back combination, with its elements separated, as shown in Fig. 132, and not cemented in the usual manner. For photographic portraiture it is necessary that the front combination should be as large or nearly so as the back, but this does not apply to an objective that is required for the production of enlarged images only, and the reduction of the diameter of the front lens prevents "fogging," or that reduction of the brilliancy of the image, through diffused light, to which I have previously referred. On the other hand, equality in the diameter of the portrait lens presents this advantage, that if the screw-fittings of the back and front combinations be of the same gauge, if a long-focussed lens is required, we have only to remove the back combination and screw the front one in its place (consequently in a reversed position), which Monckhoven's arrangement does not admit of. Again, it must be noted, that while of late years quarter-plate portrait lenses have been made so that the long-focussed front combination can be used for landscape work in the manner above described, nevertheless such combinations are not the best form of single achromatics that can be employed, as something must be sacrificed to make them work to the best advantage in conjunction with the back combination as a portrait lens.

The smaller the picture required the nearer must the lantern be placed to the screen, and the further must the power be racked away from the slide, and *vice versâ*. In focussing for the sharpest definition, if the screen is some distance off, it is well to observe the image with an opera-glass, as the eyes of the operator are liable to get dazzled with the bright light; but observe, if coloured slides are being shown, it is better not to seek *too* sharp a focus, for then every stroke of the brush is shown as in a microscope, while a more pleasing effect is produced if the image is softened by being just out of the sharpest focus.

COTTON-SPINNING.—III.

By J. Robertson.

COMBING MACHINE—DRAWING-FRAME.

The importance of cotton-spinning as a branch of the great manufacture which has become the staple of this country, and which affords the chief source of support to the thousands of busy operatives who are to be found in the manufacturing towns and districts of Lancashire and Yorkshire, can scarcely be overrated, as on its management depends the preparation of the yarns from which are woven the various kinds of cotton cloth ranging from the fine and semi-transparent muslin to the coarse and substantial fustian. There is not one of us throughout the length and breadth of the United Kingdom, from the highest to the lowest in the land, who does not at some time of the year wear some article manufactured from the fibres of the useful cotton plant, while much of many miles of cotton cloth of one kind or another which are turned out yearly by British weavers from British looms are sent across the seas into all parts of our colonial possessions, and even to the very countries which were the cradle of the weaver's art. We can scarcely, then, dwell too much at length on the machinery employed in cotton-spinning, or fear to be too diffuse in giving an explanation of the working of each machine and the results of its action on the cotton fibre, when we reflect on the importance of this art as a branch of British industry.

Of late years a combing machine has been largely introduced instead of the second carding-engine. Although combing does not form a necessary step in the preparation of the cotton, it yet requires a special notice. For fine counts and for sewing thread it far surpasses the carding-engine, being much more efficient in removing the short fibres which tend to weaken the yarn. It can only operate upon carded cotton, as it is essential that the fibres be presented to the combs longitudinally.

The principle of this machine may be better understood by a reference to the accompanying sketch (Fig. 1). The lap, A, is unwound without any strain being put upon it—just as at the finishing carding-engine—passes between the feeding rollers B and B′, and also between the "cushion-plate," D, which is covered with leather, and the nipper, C. The feed-rollers have an intermittent motion, and allow a little less of the fleece to pass at a time than is equal to the length of fibre which is to be combed and retained. No sooner do the rollers stop than the nipper comes down upon the cushion-plate, which is held in its place by a spring, and pushes it back, until the fibres which have been caught between them are in the best position for being acted upon by the roller E, on one part of whose circumference there are about a score of combs. Each of these in succession is finer than its predecessor, there being about thirty teeth to the lineal inch in the first and about 100 in the last. When these combs have passed through the portion of lap held to them, the nipper and cushion-plate move forward to their former position, where the cotton is caught between the roller G and the corrugated segment of the roller E. Simultaneously, the fine comb F drops into the tuft, and the nipper rises. As the cotton which has been combed passes forward, the tail-ends of the fibres are straightened by the comb F, which at the same time prevents those whose front ends have not been combed from going forward. To make a continuous sliver the rollers G and G′ turn backward slightly before drawing forward the cotton, so that each successive tuft is "pieced" to the one preceding. Several slivers are then combined and coiled in a can. The short staple cotton which has been taken out by the combs is stripped off them by the revolving brush H, which throws it upon a card-clothed doffer, J. This doffer has the fibres taken from it by a reciprocating comb, K, as in the carding-engine. The sliver thus produced is available for coarse yarns.

The part which the drawing-frame acts in the preparatory operations of the spinning factory is one of great importance. The cotton fibre is naturally undulating and sinuous, and this characteristic is to be found in the fibres composing the sliver produced by the carding-engine, preventing them from lying so parallel and close upon each other as it is desirable that they should before being twisted or spun. The principle upon which the drawing-frame operates to remedy this, and to equalise the grist of the slivers, is that of doubling and drawing, or elongating by means of rollers revolving at different velocities. This machine is exceedingly simple in its construction. Upon a suitable stand or support is placed a series of rollers, about $1\frac{1}{4}$ inches in diameter, in pairs, as seen in Figs. 2 and 3. The lower ones are fluted, whilst the top ones are, with the exception of the first which is also fluted, clothed with flannel and leather nicely pieced together at the edges so as to form a perfectly smooth and unbroken surface, and at the same time to be somewhat elastic. These rollers perform the same functions which the finger and thumb were wont to perform before the introduction of machinery. Six or eight slivers from the carding-engine are passed between several pairs of rollers. Now let us suppose for a moment that all these rollers revolve at the same speed, it is obvious that little or no change will be effected upon the slivers in their progress. But if the second set of rollers B revolve a half faster than the first A—that is, make $1\frac{1}{2}$ revolutions for one of A—it is equally obvious that the sliver will be drawn out, the fibres gliding upon one another, until it is a half longer. And so likewise in the case of the third and fourth rollers, C and D. But in their case the "draught," as it is technically called, is so very much increased that the combined slivers are delivered as one of about the same size as one of those of which it is composed. No precise amount of doubling and drawing can be fixed upon as neither less nor more than sufficient. It may be supposed that the oftener the cotton is drawn and re-drawn, the more thoroughly would the slivers be equalised in size, and the component fibres straightened and consolidated. In practice it is considered that a sufficient approximation to perfection is made by the use of a drawing-frame of three "heads" of four "deliveries" each. These "heads" are, indeed, complete machines in themselves, for whilst the framing and main driving shaft are common to all three, the rollers of each are driven independently. Against each "delivery" there are stops and other necessaries for eight supply-cans, so that any number of slivers up to eight can be combined as is thought best for the particular class of cotton which is in process. Short staple cotton usually requires less drawing than long staple, long fibres

being much more liable to double up in the carding than the others. Suppose, then, that eight slivers are combined and drawn into one at the first head; eight slivers from the first head are combined and re-drawn at the second; and again from the second eight slivers are drawn at the third, the result is that the finished sliver has undergone 512 doublings and drawings. It is found that the drawing is better performed when the first and second pairs of rollers run about the same speed, in fact act simply as conductors, whilst one-half of the drawing is accomplished between the third and fourth. As it is of immense importance to have the rollers adjusted to suit the staple of the cotton, they are constructed with movable bearings, so that they can be shifted to a greater or less distance apart. Should the distance between the points of contact in the different sets of rollers be less than the length of the staple, the result will be that the fibres, held by the one and drawn by the other, will be torn, to the great weakening of the yarn when finished. On the other hand, care must be taken to see that the rollers are not so widely apart that the attenuated sliver is in danger of falling asunder from its own weight. To prevent unevenness and clouding in the drawn web it is necessary to have the circumferences of the upper and lower rollers pressed firmly together, so that there may be no slip of the cotton; and for the same reason it is desirable to have as light a sliver as possible. When it is too bulky the edges are apt to be drawn away more freely than the centre part, which bears the principal weight. There is another difficulty which is felt to be somewhat serious. The rollers are generally made with two separate bosses, which it is not always possible to clothe with exactly the same thickness of flannel and leather, and the consequence is that the smaller one is driven more rapidly than the other would be if working by itself, which causes abrasion of the surfaces. To remedy this an improved roller has been invented, in which the bosses are made separately and run loose upon the roller. This system of loose bosses is now very generally adopted for the front roller where the work performed is greatest.

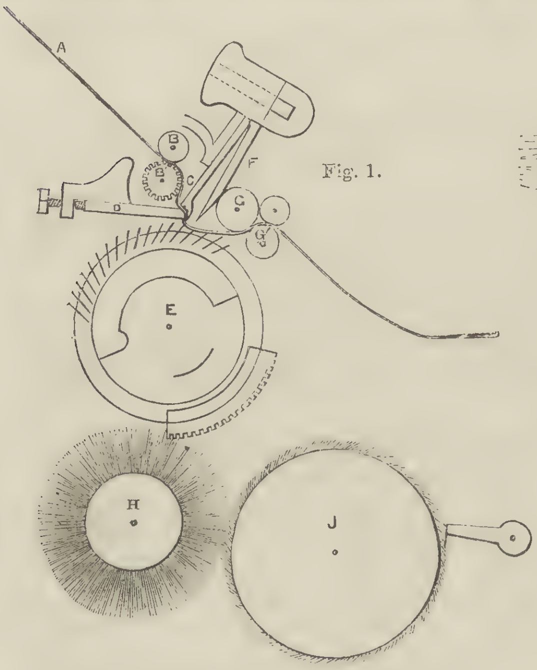


Fig. 1.

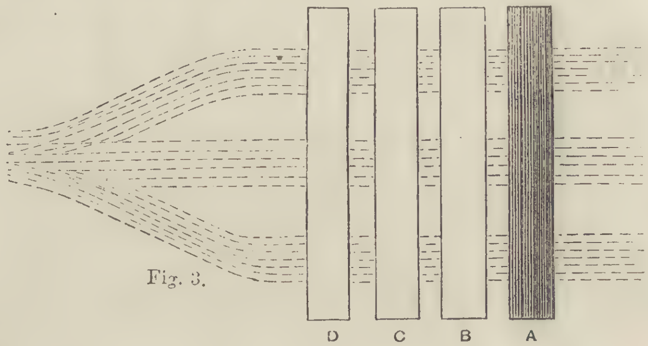


Fig. 3.

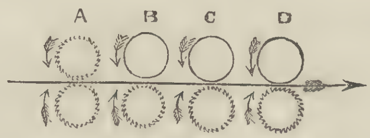


Fig. 2.

On the top of the rollers a piece of wood covered with flannel rests, which serves as cleaner to sweep off any fibres which may have adhered to them and to keep their surfaces smooth and polished. To prevent the inequality which would arise from the rollers continuing to revolve after one or more of the slivers have run out or broken, stops are introduced, which are acted upon individually by the slivers before they reach the first drawing-roller. A lever, furnished on the top end with a hollow or recess in which the sliver runs, is balanced so that, on the weight of the sliver being withdrawn, it rises, and, by a very simple connection with the belt-guide, throws the belt upon a loose pulley, and instantly stops the rollers. In the event of the slivers at the delivering side of the machine lapping round the rollers or breaking, a similarly balanced lever also brings the machine to a stand. The leather upon the rollers of the drawing-frame is very liable to be affected by damp, and it is of importance to have the atmosphere of the apartment in which they are placed thoroughly dry. The adhesiveness caused by dampness inclines the cotton to lap round the rollers, and sometimes great annoyance and trouble is caused by this, not only in the drawing-frame rollers, but in the rollers of all the subsequent machines.

The equalising of the slivers and the straightening and laying parallel of the fibres has now been sufficiently accomplished to render it fit to be carried forward another stage in the process of preparation. What now remains to be done before the cotton reaches the mule or throstle-frame is simply to reduce the sliver as nearly as possible to the size of the yarn which is to be spun. It is impossible to accomplish this by one operation. The sliver made by the drawing-frame is as fine as it is capable of being made, consistent with the strain to which it is subjected in being withdrawn from the can, with a view to further development. At each of the next stages, therefore, its further attenuation renders it necessary to have it strengthened by imparting a slight twist. This is done in the fly-frames. A machine has recently been invented to supersede the slubbing or first fly-frame, called the duplex slubbing-frame. It is somewhat similar in its action to the drawing-frame until the sliver, which has been greatly attenuated, issues from the last roller. Here, instead of being conveyed by calendar rollers directly to the coiler, it is first passed through a tube, and brought out by an eye upon one side of it. This tube revolves at a considerable velocity, and imparts a corresponding amount of twist to it, until it escapes from the tube, when the twist is again undone. This machine serves its purpose very well, the sliver being found sufficiently strengthened by the consolidation which the temporary twist has given to the fibres. Its chief recommendation is its cheapness and simplicity. The sliver from this machine is taken to the second or intermediate fly-frame. Other machines have been patented likewise for doing away with one of the more costly fly-frames, but none of them have up to the present time proved successful. This frame has not been sufficiently long in use to enable a proper estimate of its merits to be made.

MINING AND QUARRYING.—XXXVII.

BY GEORGE GLADSTONE, F.C.S.

SALT (*continued*).

MINING AT NORTHWICH—WIELICZKA—BEX—BRINE WELLS—MANUFACTURE FROM BRINE IN ENGLAND—FROM SEA-WATER BY EVAPORATION—BY FREEZING.

THE mining of rock salt must now be considered, though the product is not used to any very great extent in this country in the condition in which it is raised from below. A good deal, however, of the purest rock is exported as such; the rest is usually too much impregnated or intermixed with clay, gypsum, and oxide of iron, to be employed without first undergoing a process for the separation of these impurities.

If the bed of salt is large and solid, as at Northwich, the mine crystals of transparent rock salt resembling, in the dim light of the mine, those of felspar in the granite. In some of the large excavations referred to in the previous article the amount of staging built up of timber is very considerable: this not only serves to prevent accidents from the giving way of the roof, but facilitates access to different levels. The salt is worked out by gangs of miners, who, with a sharp-pointed pick, undercut the rock at the level of the floor, and divide the face of the working also into compartments by perpendicular grooves about ten feet apart; the masses thus isolated are then removed by blasting, and the fragments brought down by the explosion are trimmed into rectangular blocks, and removed in trucks, which run upon trams to the shaft bottom, to be brought to surface. The salt is sold in blocks just in the condition in which they are raised, and it is so pure as to be fit even for domestic use. The water, which

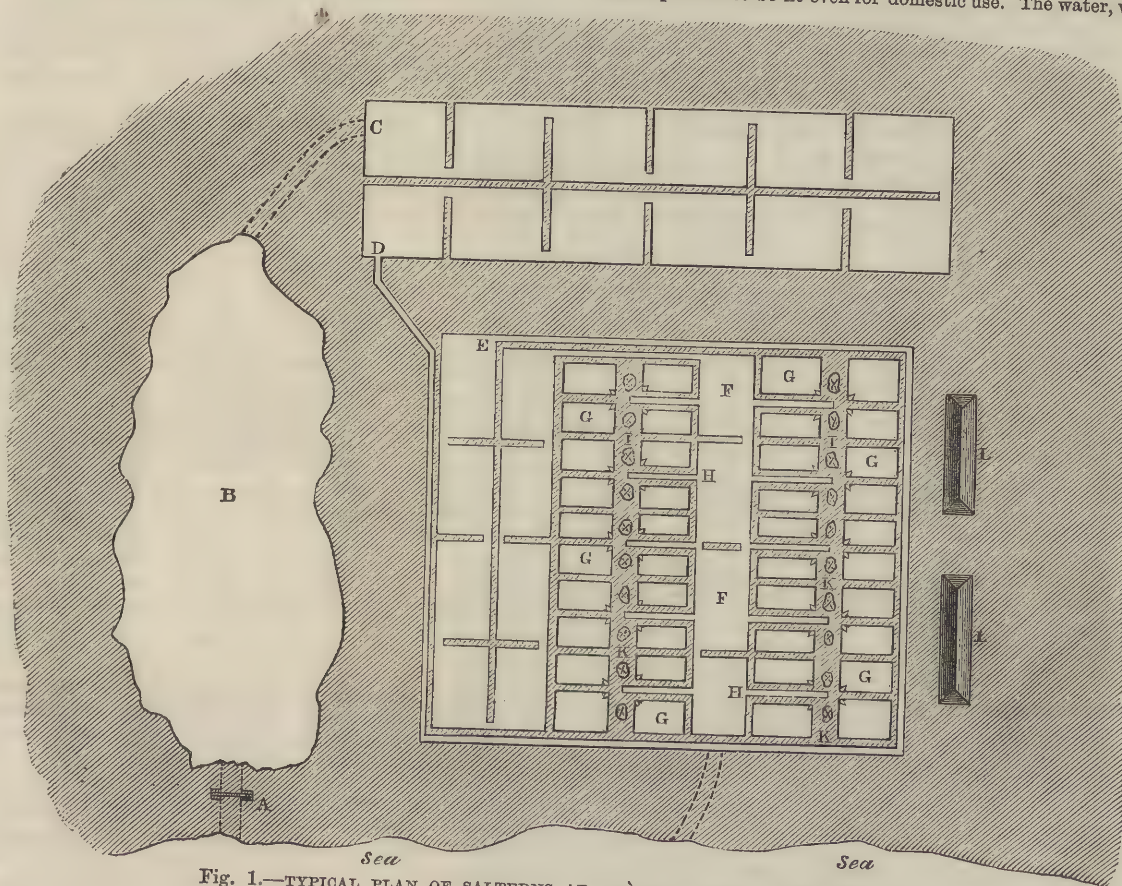


Fig. 1.—TYPICAL PLAN OF SALTERNS AT HYÈRES, CAGLIARI, TRAPANI, ETC.

is often not only free from water, but very dry. In such case the shaft is sunk as in ordinary mines, cased with timber, and divided into the necessary compartments for hauling up the produce, for fixing the ladders required in descending and ascending, etc. The hauling is usually done by steam-power. The underground workings consist of galleries driven through the rock, opening out into wider spaces where the nature of the deposit encourages more extensive workings, and especially where a good and firm roof can be obtained. Where the roof is tender large pillars of rock salt are left to support it, or it is propped up with timber.

At Wieliczka the thick beds of rock salt are perfectly dry, and the only moisture that is observable in the upper part of the mine occurs in the earthy partings. These strata being rather soft, the drifts through them are frequently timbered and boarded, and a wooden gutter is made to carry off any little water that may issue; but in driving through the salt the rock itself forms the side walls and roof, and presents very much the appearance of a light-grey granite, the large unbroken

in one part of the workings is abundant, is collected into a couple of lakes united by a canal at the bottom of the mine, the whole of which is excavated in the salt itself, the latter not being affected by the water, as it consists of a saturated brine.

The mines of Bex in Switzerland present a complete contrast to this one. The workings there consist of a long horizontal drift into the side of the mountain, opening out into spacious excavations and shafts to other levels; but throughout the whole mine water is continually dripping from above, so that it has to be collected into great reservoirs, and the salt is obtained in a state of solution just as in the case of a brine spring. The salt mines in the Eastern Alps (Tyrol and Salzkammergut) partake of much the same character.

The brine-springs themselves most commonly proceed from the saliferous marls which immediately overlie the solid salt; and in utilising them it is desirable to secure as strong a brine as possible. It is usual, therefore, to make a double casing to the well, and to ram clay into the space between the two, so as

to exclude all surface water; and when this has thoroughly consolidated, to push the boring down till the brine is met. In England steam-pumps are generally used now to raise the salt water, and pump it into the great reservoirs prepared for its reception; but on the Continent water-power is employed in the great majority of cases.

In this country the following plan is usually adopted for the purpose of separating the pure salt. The solid mineral, being generally impregnated with iron and other impurities, is thrown into the reservoirs just referred to, so that the brine is kept up to the saturation-point. The liquor is drawn off as required into the evaporating pans, which are shallow vessels of wrought iron having an area of 1,000 to 1,800 feet, and a depth rarely exceeding eighteen inches. They are oblong in shape, the length usually about three times the breadth, and the furnaces for heating them are placed at one of the narrow ends and the flue at the other, the floor of the pan resting upon iron supports around which the fire plays. The two long sides of the pan are occupied by the workpeople, who stand upon a raised platform which extends along their whole length, and immediately behind which are the moulds or strainers for the salt. As the evaporation of the water proceeds the salt necessarily begins to crystallise out, and it collects at the bottom of the pan; at the same time, however, a thin film of salt will float upon the surface of the brine, which, if allowed to remain, will impede the escape of the aqueous vapour. This pellicle, however, will not form if any oil or resin be thrown upon the surface, and as only a few grains of the latter are sufficient to prevent the setting over, even when pans of the largest size are employed, its use is decidedly advantageous.

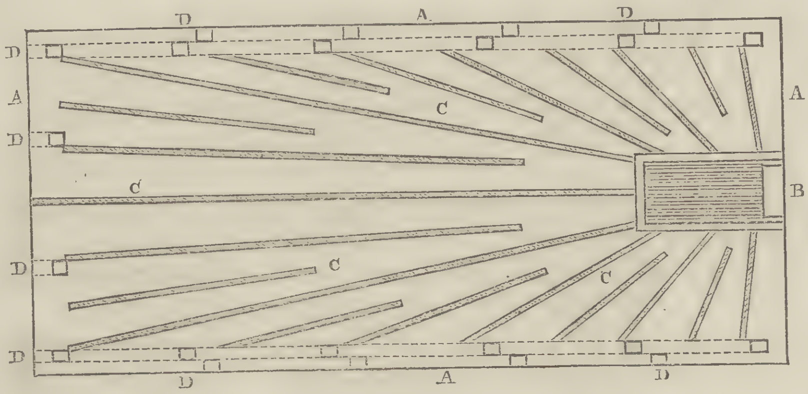


Fig. 2.

When the boiling has been continued sufficiently long to ensure a considerable deposit of salt at the bottom of the pan, the temperature is reduced, and the removal of the salt commences. The workpeople, supplied with long-handled "rakes," scrape up the salt into heaps all along each side of the pan, then they take up the wooden moulds or tubs which stand behind them, and placing them upon the ridge of salt crystals proceed to fill them. The moulds themselves correspond in shape to the familiar tapering form of the "squares" of salt, as they are called in shops. The wider end is open, and the narrower has a perforated bottom. The salt is taken up in a perforated shovel, called a "skimmer," and poured into the mould; when full to the brim the salt is worked about with a short thick stick, the "rammer," until it has subsided to about half the height of the mould, the greater part of the liquor having been forced out through the perforations and crevices. The mould is then re-filled, and the salt piled up above the level of the top; this is beaten down flat with a wooden mallet, and the mould is then set aside to drain. The squares of salt are afterwards removed to a heated chamber to be finally dried after having been taken out of the moulds.

When all the salt deposited at this boiling has been removed, fresh brine is let into the pan to fill it again, the fires are got up afresh, and the same process is repeated. Three batches of salt may thus be withdrawn from each pan in the course of the day. As the operation is a continuous one, and the liquor remaining is not withdrawn, but is left to mix with the fresh brine, the carbonate and sulphate of lime, a small quantity of which is generally to be found associated with the chloride of sodium, gradually accumulates on the bottom of the pan, and if allowed to remain would exercise the same injurious effect that the fur does on the inside of boilers. This "pan scratch" has therefore to be removed periodically by means of sharp picks; and it is used for mixing with refuse salt, to be sold to agriculturists.

At the salt works of Dürrenberg, in Prussian Saxony, a very good arrangement is in use for the economical evaporation of the brine; and every plan which tends to effect a saving in that most precious article, fuel, is well deserving of attention. The pans used have an area of about 1,060 square feet, and each is heated by a single furnace, the grate of which measures eighteen square feet, and the supports for the pan radiate from the furnace, as shown in Fig. 2. A represents the size of the pan, B the fire-grate, and C, C the supports, which are so arranged as to distribute the heat effectively before passing into the flues D, D. The supports are broad below, but taper as they rise, so that the part of them on which the floor of the pan rests is only $1\frac{1}{2}$ inch thick. The gases, after having done their work here, are carried off by the flues into the stoving-room, where they are made to do duty a second time in drying the salt. In this room the flues are conducted between a series of racks, upon which the baskets are placed when filled with the salt crystals taken out of the pan.

Stoved salt, the manufacture of which has been already described, is very fine in the grain, because the crystals have been formed rapidly, and the liquor has been kept in agitation all the time by being on the boil. Coarse or large grained salt is made at a low temperature, sometimes at only 100° to 110°, so that the evaporation is very gradual, and the salt has time to develop into large solid cubic crystals. In such case five or six days will be required for the evaporation of the water. Intermediate descriptions will be obtained by adopting suitable temperatures ranging between this last and the boiling-point. The grain of the salt yielded by a pan of large size will indeed vary, as the parts nearest to the furnaces will be the hottest, and therefore yield smaller crystals than those more remote. Each of these descriptions of salt has its special applications.

The manufacture of sea salt has almost died out of this country, as the climate is unfavourable for conducting the operation in the economical way adopted in the warmer regions of the south of Europe. In former days, however, when salt was much dearer than it is now, the sea-water used to be concentrated in salterns, and then evaporated down by artificial heat until the whole of the salt was deposited. The salterns now in use at Hyères, Cagliari, Trapani, and other places on the shores of the Mediterranean, are laid out on a very extensive scale. The plan (Fig. 1) in the preceding page will show the principle upon which the operation is carried on. They extend along the flat shores, protected by a sufficient embankment from the rise of the tide. A flood-gate at A admits the sea at high water into the collecting pond B, in which any sand or other matter mechanically suspended in the water is deposited, before the latter is admitted into the salt gardens. These are so arranged and subdivided by embankments that the water has to perform a long course before it reaches the crystallising ponds. The sun and the hot air of the summer months causes so great an evaporation that sometimes the salt will be deposited after a single day's exposure, though two or three days are more generally required. From the collecting pond the water passes into the first pool at C, and has to traverse this one to the extreme end and back again, before reaching the exit at D. This pool is made very shallow, so that a large surface of water is exposed to the heat of the atmosphere, and the evaporation is proportionally great. From D the channel passes round the saltern,

and the water enters the second series of ponds at E, and after making the circuit of these, passes into those marked F. By this time the water is just about fully saturated with salt, and as soon as it is found to be ready to crystallise out, the brine is drawn off into the crystallising ponds G, G. Each of the small channels H, H will be observed to supply four of these ponds, through a pipe entering at the nearest corner, which is opened and closed, as required, by a wooden plug. The salt is raked out and piled in heaps, I I, on the platforms K K, which run between the two series of crystallising ponds; the mother liquor drains out and flows back into the latter, and when the salt no longer continues to form, the spent liquid is drawn off and allowed to run into the sea. The salt, after it has drained dry, is removed from K and made into large heaps as at L, which are covered with straw to keep off the rain: it remains here until the chloride of magnesium, which is always present in freshly-made sea salt, and which is very deliquescent, has absorbed sufficient moisture from the atmosphere to become melted, and has drained away. The remaining salt will then be sufficiently pure for use.

There is another mode of separating salt from sea-water which is sometimes practised, and which depends upon a totally different principle. Cold, instead of heat, is used in this case for the purpose of making a concentrated brine; and it is practically applied with advantage on the shores of Eastern Siberia and other northern regions where an intense degree of cold prevails in winter. It is a matter of familiar experience that salt water does not freeze so readily as fresh, and it is found that in freezing a change takes place in the arrangement of the particles whereby the saline ingredients are to a great extent separated from the rest, and remain in a liquid state while the water thus deprived of the greater part of the salts is converted into ice. By this means a tolerably concentrated brine can be obtained, from which the salt can be crystallised out with a slight expenditure of fuel. Sea-water, however, contains salts of calcium and magnesium as well as sodium, and under the influence of cold the sulphate of magnesia and chloride of sodium will mutually decompose each other, forming sulphate of soda, otherwise known as Glauber's salts, and chloride of magnesium. These, as well as other substances formed in the salt thus prepared, render its use undesirable as an article of food.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Galletly, Curator, Industrial Museum, Edinburgh.

V.—MANUFACTURE OF WOOLLEN CLOTH.

If we compare together a piece of superfine broad cloth and a piece of any worsted fabric, say "merino," we shall find that in the former there is no appearance of its being woven, because after the process of felting, which all such cloth undergoes, the warp and weft threads are hidden from view; while in the worsted fabrics these threads are very distinctly seen. Since both "woollen" and "worsted" goods are composed of the same animal fibre, it seems strange to say that they are prepared by unlike processes; by machines which are not only different, but opposite in principle; and by workpeople whose experience in the production of the one class of fabric is of little or no service in the manufacture of the other. Such, however, is the case, and the reasons for these differences will appear as we proceed. The maker of fine broad cloths aims, as Mr. George Leach, of Leeds, himself a manufacturer, expresses it, at making a fabric which will "resemble as much as possible a fine short fur." To obtain this result, "woollen yarn" requires to be prepared with the fibres in great part transverse to the axis of the thread; in fact so that, if magnified enough, it may roughly resemble a bottle brush, where the projecting bristles would represent the "pile," and the twisted wire the inner portion or heart of the yarn. It is these projecting portions of the wool which interlock and mat together in the milling process, and which, with many additional points, are afterwards raised by the teazles and cropped to a uniform length, so as to leave a smooth even surface on the cloth.

The worsted manufacturer, on the other hand, requires his yarn to have the fibres as much as possible parallel to each other, so that it may be even, strong, and composed of few filaments. Worsted yarn is besides always harder spun than woollen, the latter being but slightly twisted in order to leave the fibres as free as may be for the felting process. The quality of worsted goods depends in great part on the softness and rich appearance, as well as the fineness of the yarn, these properties giving its character to the finished fabric, in which the number of threads in a given space can be easily counted. With this brief description of the difference between woollens and worsteds, we proceed to explain the successive stages in the production of woollen cloth, stating at the outset that the processes are more numerous and complicated than those of any other textile manufacture, and are performed by a greater variety of machines and workpeople. It will be useful to give here a full table of these processes, as a sort of key to what follows, it being only necessary to describe in detail the more important ones.

The various stages in the manufacture of woollen cloth, then, are:—1. Wool as shorn from the sheep and sorted into different kinds. 2. Scouring in alkaline liquor. 3. Washing after scouring. 4. Drying in drying machine or heated chamber. 5. Dyeing when dyed in the wool. 6. Willowing or dusting. 7. Cleaning by burring machine. 8. Oiling and teasing. 9. Scribbling by first carding-engine. 10. Carding by intermediate carding-engine. 11. Carding by finisher carding-engine, and forming sliver by condenser. 12. Spinning into yarn, "warp or weft." 13. Warping. 14. Sizing. 15. Weaving into cloth "raw-thread." 16. Scouring. 17. Burling. 18. Milling or fulling. 19. Scouring again. 20. Drying or tentering. 21. Raising or teazling. 22. Shearing or cutting. 23. Brushing by revolving brushes. 24. Pressing. 25. Boiling and cleansing. (25*a*. Dyeing when piece-dyed.) 26. Shearing again. 27. Picking, drawing, or marking. 28. Pressing again. 29. Steaming. 30. Folding or packing.

Wool used for any special branch of manufacture is selected from certain parts of the fleece, which is accordingly divided into "sorts" or qualities by experienced sorters or staplers. The number of these sorts vary in different fleeces, but they are seldom fewer than six, and sometimes as many as twelve. In the case of a German fleece divided into six portions, the various kinds are thus described by Professor Archer, in his report on the International Exhibition of 1871:—The *first* is that which grows upon the flanks and ribs near the shoulder; the *second* is from the lower part of the haunches; the *third* is from the part extending from the shoulders down to the knees; the *fourth* is from under the neck; the *fifth* from the hinder part to the tail and beginning of the back; and the *sixth* is from the head, between the thighs, and from the breech But this disposition of the various qualities is subject to much variation, which the skilled judgment of the stapler at once detects.

After the sorting, the first process is *scouring*, by which the wool is cleansed from the grease with which it is naturally impregnated. Upon the care taken at this stage depends much of the success of succeeding operations, but especially of the dyeing, which can neither be brilliant nor permanent if the scouring is inefficiently performed. Previous to 1853 it was usually done by hand. In that year Mr. J. Petrie, jun., of Rochdale, patented a wool-scouring machine. This excellent machine consists of a long trough containing alkaline lye, in which four rakes are made to "pass or drag the wool automatically from the continual in-feed of wool until it reaches the new patent slide-lifter, which transfers it in regular quantities, according to the feed, to the squeezing rollers." These rollers express the surplus liquor, and the wool is then thoroughly washed in water as pure and soft as possible. The apparently simple operation of drying the wool requires careful attention, because if either too much or too suddenly heated, it becomes harsh and brittle. A very efficient plan is to spread the wool on galvanised wire-work, and then blow either hot or cold air through it by means of a blast-fan. This dissipates the moisture while it retains the natural softness of the fibre.

Passing for the present the dyeing, which takes place at this stage when "wool-dyeing" is resorted to, we come next to the *willowing* or *willying* process, which opens and disentangles the locks of wool, and so clears it of sand, dust, seeds, and other impurities. The willow, or as it is sometimes called, the devilling machine, is of various forms, a vertical section of one being shown in Fig. 17. It consists of an open cylinder or drum, (C), with twelve ribs, on each of which is a row of spikes. Three rollers (B), each with ten rows of similar spikes, are placed over

the drum, so that when the machine is in motion the spikes on the rollers pass through the spaces between those on the drum. By this arrangement, coupled with the rapid motion of the machine, the wool is opened, and the impurities which separate fall through the wire cloth (W).

Many wools contain peculiar seeds, called "burrs" and "moiets," very difficult to remove, as they are covered with prickles, which adhere firmly to the fleece. To clean the wool of these troublesome seeds, the *burring machine* was brought into requisition, and, like the willy, it is of different forms. One of the best is manufactured by Platt, Brothers, and Co., Oldham, who thus describe its action:—"The wool is fed upon a travelling cloth or table through a feed-roller and dish to the action of a beater, and delivered to a series of rollers to charge the first fine-comb cylinder; the surplus wool-burrs, etc., from the cylinder are stripped by a guard-roller, and deposited upon a second series of rollers, and delivered by them to a second comb cylinder, which is stripped like the first; the strips are deposited on a grid, which allows the burrs and impurities to fall through, but retains the fibre to be transferred by a series of vibrating combs to the rollers and re-charged upon the cylinder until it is freed from all foreign matter. The burrs and other impurities are thus dropped through the grid to the floor."

At this stage, in order to remove harshness and give it greater elasticity to undergo the spinning processes, the wool is sprinkled with oil; and afterwards in the same machine it is what is called "prepared," that is, the matted portions are torn open to make it more easily carded. The machine is termed a "wool-oiling and preparing machine." The oiling apparatus is so constructed that the oil, by means of a series of jets or gutters, falls in a kind of cascade on the wool as it passes along the "feed" to the teasing cylinder, which revolves at a high speed, and is covered with steel teeth to separate and loosen the wool into small tufts, which are then thrown out on the floor ready for carding.

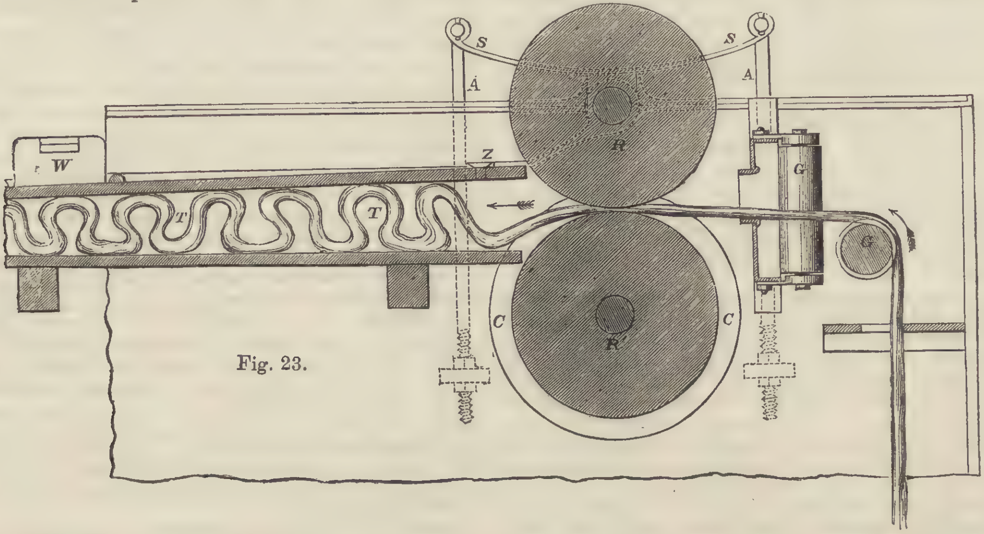


Fig. 23.

Carding is one of the most important operations in the manufacture of woollen cloth, because the quality of the yarn greatly depends on the manner in which it is executed, it not being easy to remedy the effects of defective carding in the subsequent stages. There are usually three machines employed in the process—namely, the scribbler or first carding-engine, the intermediate or second carding-engine, and the finisher carding-engine and condenser. The general construction of these machines will be understood by examining Fig. 18, which is a simplified longitudinal section of the last carding-engine and condenser. It consists of a large cylinder (C), surrounded by a number of small rollers called "workers" (W) and "strippers" (S). There is also a doffing cylinder (D), and one or two others. All these are covered with cards or brushes of wire, the points of which on the main cylinder and on the workers incline in opposite directions, so as to card the wool by opening, mixing, and blending the fibres till they form one thin, continuous, uniform sheet or flake of wool. In the case of the strippers or

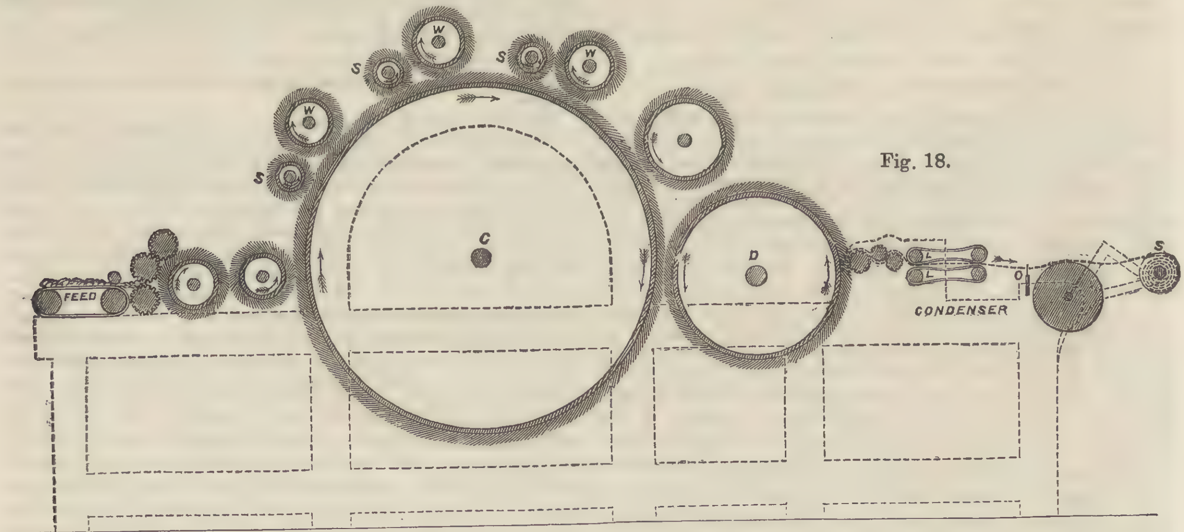


Fig. 18.

cleaners, the teeth move in the same direction as those on the workers and cylinder, so as to clean or "float" off the wool from the worker and deposit it again on the cylinder. Fig. 19 shows the relative position of the teeth on the workers and main cylinder, and Fig. 20 those of the strippers and workers. These two figures also show the angle at which the carding teeth are set, and Fig. 21 shows how they are fixed into the leather or india-rubber which covers the rollers. The three carding-engines have their teeth formed of wire of different sizes, the first being the coarsest and the last the finest. In some of the newer sets of engines there are on the first 500 points to the square inch, on the second 600, and on the third 700. Not more than one-eightieth to one-ninetieth of an inch of space intervenes between the card-surfaces of the cylinder, workers, and doffer, from which an idea can be formed of the great nicety required in adjusting the various parts of a carding-engine.

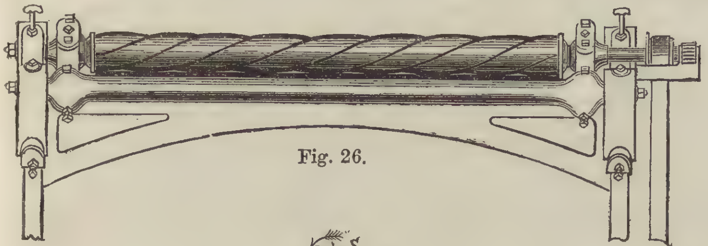


Fig. 26.

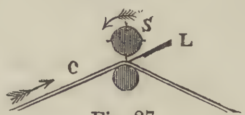


Fig. 27.

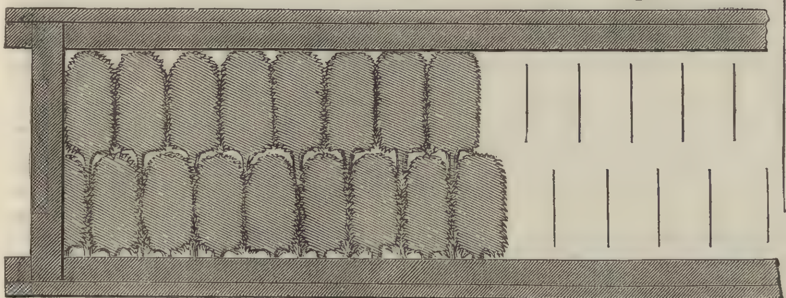


Fig. 25.

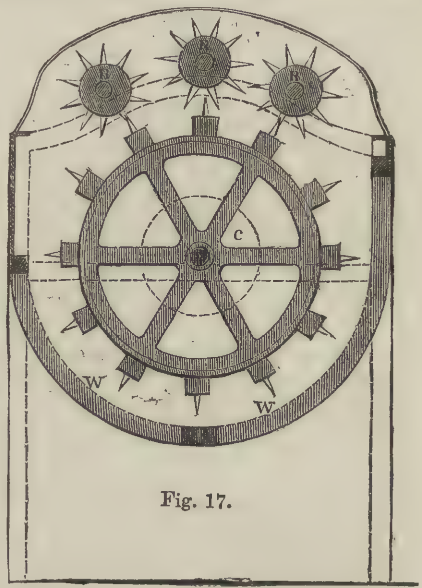


Fig. 17.

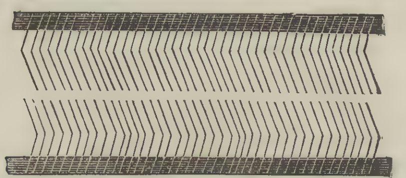


Fig. 19.

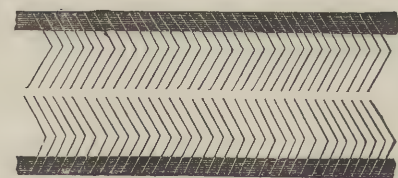


Fig. 20.

Fig. 24.

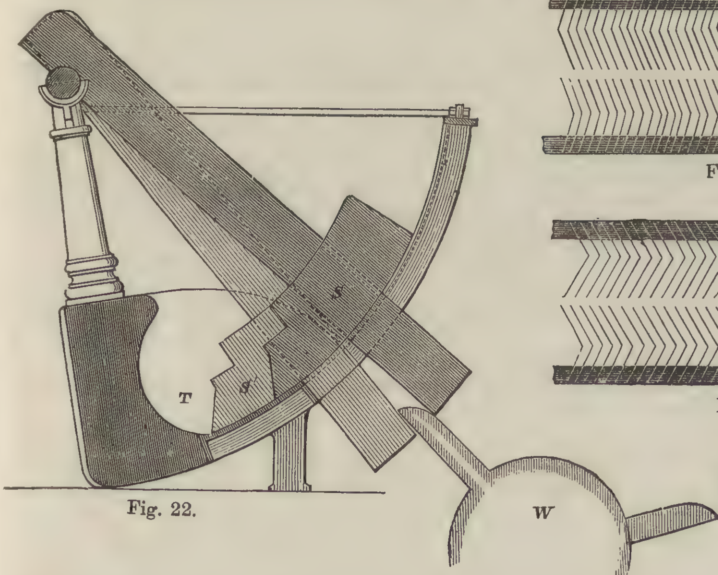


Fig. 22.

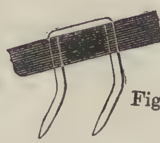


Fig. 21.

When the carded fleece reaches the doffer (D), which, with the exception of some recently-introduced kinds, has its card-surface divided into a number of strips or parallel rings with spaces between them, it is then acted upon by the *condenser*, so called from its forming the wool into slubbings before leaving the carding-engine, instead of this being done by a separate machine, formerly in use, and termed a "slubbing-billy." In Fairbairn's condenser, which is the one indicated in Fig. 18, the fleece is divided by thin steel blades as the doffer revolves towards them. These strips are caught by small grooved rollers, and carried forward between two endless sheets of leather or rubbers (L, L), which are stretched on pairs of rollers hung in frames, having a transverse alternate motion which rolls the strips into "slivers" or "slubbings." These condensed slivers—the first form of the yarn—each pass through separate wire loops (O) over a wooden roller, and are wound on two rows of bobbins or spools,

of which, however, only one (s) is shown in the figure, the other being situated right below it. The dotted line (Fig. 18) shows the course of sliver on the condenser. Some condensers divide the fleece into as many as 120 slivers.

Spinning.—Woollen yarn is sometimes spun on a machine resembling the throstle used in spinning cotton, but much more commonly on a *mule* which also resembles those in use in the cotton manufacture, although considerable modifications are required when wool is the material to be spun. Without elaborate engravings it would not be easy to make intelligible the different parts of so complicated a machine as a self-acting mule, but we may briefly mention its chief parts. It consists of a *fixed and a movable portion*, and upon the first of these the bobbins, with the condensed sliver or slubbing and the drawing-out rollers, are placed. The ingenious construction of these famous rollers, invented by Louis Paul, in 1738, has been of great and enormous benefit to the textile industries. In his original patent, after stating that the first pair draw in the sliver of cotton or wool, he thus clearly describes their action:—"As the cotton passes regularly through or betwixt these rollers, a succession of *other rollers, moving proportionally faster* than the first, *draw the sliver* into *any degree of fineness* that may be required." The movable portion of the mule carries the spindles, which twist and receive the yarn, and is a sort of carriage moving upon iron rails. Besides that of the drawing-rollers, there is a motion for giving out from the bobbins the length of sliver to be spun, another for giving the yarn the requisite twist, and another for winding the yarn on the spindles. But there are a number more, and perhaps we could not, in a few words, give a better general idea of these than to state that the fine self-acting woollen mule shown in the International Exhibition of 1871 by Platt Brothers and Co. had "192 spindles, $2\frac{1}{8}$ inches apart, to spin from condenser bobbins, and with creel for second spinning, double-speed motion, twisting-in or drawback motion, twist motion, stop motion for stopping the mule, governor and quadrant regulating motion, spindle-stopping motion, positive cam-shaft motion, friction taking-in motion, long copping rail and double copping or shaper plates, and motion for putting the double speed on at any part of the draw or stretch."

Winding, Warping, and Sizing.—These operations are all done upon special machines; the first consists in winding the yarn from the mule cops on "warper's bobbins;" the second in taking the yarn off these bobbins and forming them into a "warp" with the threads parallel to each other; and the third in sizing the warp threads with hot glue or other size so that they may have strength enough to bear the tension to which they are subjected in the loom.

Weaving.—On account of the comparatively slight twist which is given to woollen yarn—thus enabling it to felt easily—it is more difficult to weave in the power-loom than worsted, cotton, silk, or linen. Power-looms for woollen goods are consequently of comparatively recent introduction, and all the more important advances have been made since 1851. As the power-loom employed in weaving woollens is of the same construction as those used for other textile manufactures, we need not attempt to describe its details here. The cloth just taken from the loom is called the "raw thread," and has still to pass through the felting and afterwards through what are called the finishing processes. At this stage, as has been already explained, woollen cloth shows the warp and weft threads as well as a piece of worsted fabric. Subsequent operations, however, totally change the appearance of its surface.

Scouring.—The newly-woven cloth requires to be scoured or brayed in order to remove both the oil applied to the wool before carding, and the size used to stiffen the yarn for the weaving process. The scouring is effected by steeping the cloth in alkaline liquor, and beating it in the fulling stocks or passing it between heavy rollers. Afterwards it is put through clean water, dried, and examined by the *burler*, who carefully removes any knots or burls, and rectifies any imperfections in the weaving.

Milling or Fulling.—This is one of the most interesting of all the processes carried on in a woollen mill. By it, through the combined action of heat, friction, and moisture, the cloth is *felted*, that is, the fibres of the wool, by reason of their minutely jagged or serrated edges, interlock or hook into each other, thereby strengthening, thickening, and forming, as it were, a new matted surface on the cloth. The old way of both scouring and milling, now almost entirely gone out of use, was by the "fulling stocks," which consist of heavy woollen mallets driven by cog-wheels after the manner of tilt hammers. As this machine, from the great length of time it has been employed in our woollen factories, has an historical interest, we give a representation of it in Fig. 22. The cloth is placed in the trough (T) after it has been saturated with a hot solution of soap. By means of the projecting cogs on the wheel or barrel (W), the two ponderous mallets (S, S′) alternately rise and fall, each as it descends striking the cloth with a heavy blow. This, when continued sufficiently long, felts the cloth to whatever extent is required, a thorough fulling requiring about five hours. Fuller's earth, a kind of clay with a soapy feel and detergent properties, was long used for scouring by the stocks, and large quantities of it were annually consumed, but soap is now preferred. The milling process is now usually performed by means of a machine, the essential parts of which are represented in Fig. 23. Two narrow rollers (R, R′) are placed in a frame and held down by a spring (S), which can be adjusted by means of the rods (A, A) attached to it, with nuts at their lower ends. There are in fact two such springs, one on each side of these rollers. The cloth, after having a thick solution of soap applied to it, is conducted by smaller guide-rollers (G, G) to those at R, R, which apply the pressure and force it into a long narrow trough or spout (T). The top of this spout hangs on two spring hinges, one of which is shown at Z, and weights (W) are placed at its other extremity. Here the cloth is further submitted to yielding pressure and friction. It is necessary to keep in mind that the space through which the cloth passes both at the rollers and in the spout is very confined, and that the lower roller has a metal flange (C) to prevent it spreading. This kind of milling machine, as compared with the fulling stocks, does its work with a great saving of time, space, and power, besides better regulating the width and length of the pieces. During the operations of scouring and felting the cloth shrinks in width by more than a third, and its length contracts in nearly the same proportion. After being milled it is once more scoured, and this time with great care and attention, as much of the beauty and clearness of the colour or colours in the finished fabric depend upon its being thoroughly done.

Raising or Teazling.—This is another interesting and curious process, by which from the felted surface of the cloth innumerable points of the fibre are "raised," and then sheared or cropped in the shearing machine to form the nap or pile. The operation is called teazling, because it is done by means of the ripe head of a thistle-like plant called the teazle (*Dipsacus Fullonium*), shown in Fig. 24. It is cultivated in one or two English counties, and is occasionally seen growing wild on railway embankments, roadsides, and other waste places. Its hooked scales are better suited than wire for raising the nap, because they are sufficiently strong to do this, while they yield and break under circumstances where wire would not, and so cause injury to the cloth. The teazles are arranged in frames, like the one shown in Fig. 25, which are placed on the circumference of a revolving drum, and there is a convenient arrangement of rollers for exposing the cloth to the teazle scales. The whole machine is called a gig-mill, and is of various forms, but in all the cloth moves in a contrary direction to the drum, and with a much slower motion.

Shearing.—The surface of the cloth, being now all over with raised points of unequal length, requires to be shorn to a uniform level, an operation which, like the teazling, was formerly done by hand. At the present time the shearing is for the most part effected by means of a machine called a "perpetual," consisting of a roller with cutting blades passing spirally round it, a straight piece of steel with a fine edge called a ledger blade, and an arrangement of rollers by which the cloth is brought up against the shearing blades, with proper driving-gear to set the whole in motion. Fig. 26 shows a face-view of the cutting portion of the machine, and Fig. 27 a cross-section of the same, in which S is the spiral cutter, L the ledger blade, and C the cloth. As the spiral revolves, it, together with the straight fixed blade, acts like a pair of scissors, and cuts the nap of the cloth to the desired length. Of course, in a machine doing delicate work of this kind the several parts must be very carefully adjusted, for which purpose the bearings are made compensating, and are so constructed that if the ends of the

cutting roller, for example, should wear unequally the bushes in which its ends rest, it swivels or adjusts itself so as to prevent irregular cutting. In like manner, if either the straight or spiral cutter should wear more at one side of the machine than at the other, a similar compensating action takes place. Cloth is usually "raised" twice and "cropped" several times, but the extent to which these operations are carried varies according to the nature of the finish the cloth is to receive.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVIII.—PROFESSOR SIR CHARLES WHEATSTONE.

Charles Wheatstone, the scientific inventor of the electric telegraph, was born at Gloucester in 1802. In early life, his being engaged in the manufacture of musical instruments led him to study the laws of sound; some of his experiments on acoustic figures were presented to the Royal Society in 1833, and subsequently to the Royal Institution. Next year he applied himself to the investigation of light and electricity, and experimenting upon their velocity and duration; and in the same year he was appointed Professor of Experimental Philosophy in King's College.

In 1838 Professor Wheatstone submitted to the British Association his stereoscope, the instrument invented by him for illustrating the phenomena of binocular vision. His paper was considered by Sir David Brewster to be one of the most valuable optical papers presented to the Association; while Sir John Herschel regarded Mr. Wheatstone's discovery as curious and beautiful for its simplicity. It is described in the *Philosophical Transactions*, part I., pp. 373-376, and may be thus simplified. When we look at any round object, first with one eye, and then with the other, we discover that with the right eye we see most of the right-hand side of the object, and with the left eye most of the left-hand side. These two images are combined, and we see an object which we know to be round. The instrument consists of two mirrors placed at an angle of 45 degrees, or of two semi-leaves turned with their curved sides towards each other. To view its phenomena, two pictures are obtained by the camera on photographic paper of any object in two positions, corresponding with the conditions of viewing it with the two eyes. By the mirrors or the lenses these dissimilar pictures are combined within the eye, and the vision of an actually solid object is produced from the pictures represented on a plane surface.

We now pass on to the invention of the electric telegraph. In 1819 Oersted made his grand discovery of the deflection, by a current of electricity, of a metallic needle at right angles to such current. Dr. Hamel, of St. Petersburg, states that Baron Schilling first applied Oersted's discovery to telegraphy; it is also claimed by Ampère, but his plan was very complicated; and Schilling first realised the idea by actually producing an electro-magnetic telegraph simpler in construction than that which Ampère had *imagined*. In 1836, Professor Muncke, of Heidelberg, who had inspected Schilling's apparatus, explained the same to William Fothergill Cooke, who in the following year returned to England, and, simultaneously with Professor Wheatstone, laboured for the introduction of the electro-magnetic telegraph upon the English railways; the first patent for which was taken out in the joint names of these two gentlemen, in the year 1837, and laid on the London and Blackwall Railway. The wires employed were of copper, enclosed in an iron tube, each wire being separated from its neighbour by some non-conducting material.

In 1844 Professor Wheatstone, with one of his telegraphs, formed a communication between King's College and the lofty shot tower on the opposite bank of the Thames; the wire was laid along the parapets of the terrace of Somerset House and Waterloo Bridge, and thence to the top of the tower, about 150 feet high, where a telegraph was placed; the wire then descended, and a plate of zinc attached to its extremity was plunged into the mud of the river, whilst a similar plate, attached to the extremity of the north side, was immersed in the water. The circuit was thus completed by the entire breadth of the Thames, and the telegraph acted as well as if the circuit was entirely metallic.

Meanwhile, a misunderstanding arose as to the relative positions of Messrs. Cooke and Wheatstone, in connection with the invention; when Sir Marc I. Brunel and Professor Daniell awarded Mr. Cooke to stand alone as to the practical introduction of the electric telegraph, and Professor Wheatstone as the scientific man whose remarks had prepared the public for the practical application. But the document was misinterpreted, and related only to Cooke and Wheatstone's first patent; whereas the investigations were mostly carried out by Wheatstone; and under Cooke's superintendence, a telegraphic line of fourteen miles had already been laid down upon the Great Western Railway.

A submarine electric telegraph was, from the commencement of Mr. Wheatstone's experiments, a prominent object in his thoughts, as proved by letters, in 1837; he was examined by a Parliamentary Committee in February, 1840; and in the same year he showed his plans to some of the most distinguished scientific men in France. Mr. Cooke and Mr. Wheatstone then entered into partnership, from which Mr. Cooke subsequently retired, and the subject was for a time in abeyance; but five years afterwards it was taken up from Mr. Wheatstone's starting-point, and was successfully carried out. Vice-Admiral Smyth bore testimony to Professor Wheatstone's claim of eighteen years, as "the first contriver of the electric telegraph in the form which made it available for popular use." M. de la Rive attests Mr. Wheatstone to be the first to give electro-telegraphy the practical character that it now possesses; he adds, "This illustrious philosopher was led to this beautiful result by the researches that he made in 1834 upon the velocity of electricity—researches in which he employed insulated wires of several miles in length, and which had demonstrated to him the possibility of making voltaic and electro-magnetic currents to pass through circuits of this length." In an account of the laying of the cable in the *Times*, in 1866, it was emphatically declared, "The credit of the original idea—that is, of the invention itself—belongs to Mr. Wheatstone." There is also evidence of his having "privately revealed and demonstrated his invention of telegraphic communication, and not only foretold but proved the wonders it would accomplish."

The telegraphs used in this country, where signals are transient, and must be read off one by one as they appear, are the double and single telegraphs of Cooke and Wheatstone, used by the Electric Company and the South-Eastern Railway Company—the single needle requiring one wire, and the double needle two. The telegraph of Professor Wheatstone, in which a hand points to the letter itself on a dial, is gaining ground for private use.

"The nerves of London" is the term applied to the system of wires which may be seen stretching across the sky-line of great thoroughfares, and visibly triangulating the metropolis in every direction. The battery employed to transmit the electric impulse along these delicate threads of copper is a form of the magneto-electric machine—one of the most beautiful of Faraday's splendid gifts to science. By rapid rotation, such a removal and replacement of a piece of iron before the poles of a magnet can be made, as to produce a series of electric impulses along a wire coiled around it; and electric impulses of this kind can be produced from a very small magnet, which yet possess sufficient power to work the delicate instruments, even after traversing a very considerable length of the ordinary coarse iron wire, or even miles of the extremely fine copper wire now used by Professor Wheatstone in his new cables. This system of wires may be seen vexing the eye at St. Clement Danes and St. Mary-le-Strand, the conducting wires being strained from poles on the house-tops.

The area of London being divided by a system of triangulation, the posts that form the meeting-points of three series of cables become the centres at which these multitudinous wires have to be distributed, at intervals carefully selected.

THE LATHE.—XVII.

By Henry Northcott.

LATHES FOR SPECIAL PURPOSES (*continued*).

The lathe given at Fig. 111 will show the different forms which lathes will take even when designed for similar purposes. This lathe is by the same eminent makers as the last described, and for the same class of work. But the last was capable of turning out only one wheel-tire at once, whereas this one

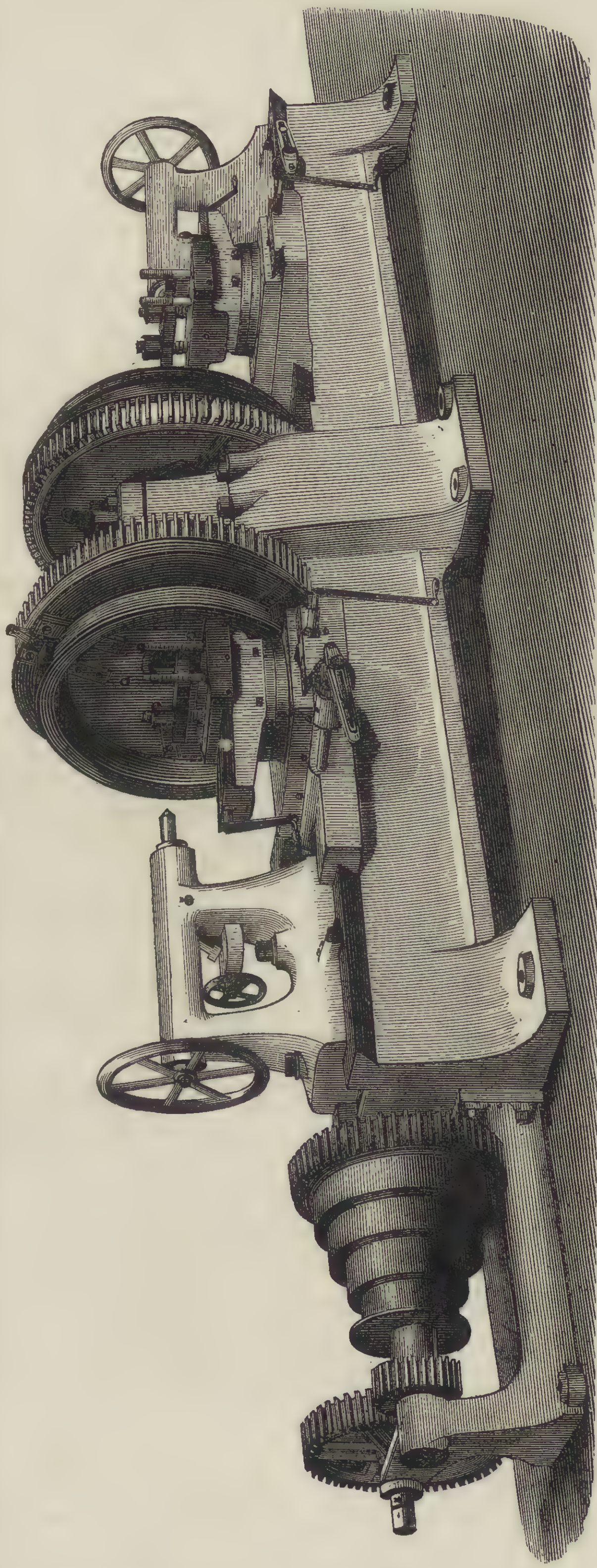


Fig. 111.—LATHE FOR BORING OUT INSIDE OF RAILWAY WHEEL-TIRES, BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

works upon two simultaneously, and as one man can attend to the double lathe a saving of labour is effected. This lathe, however, is adapted to the double purpose of boring out the tires and turning up the axles upon which the wheels are afterwards mounted. It differs in arrangement as much from the previous lathe as from ordinary self-acting lathes, inasmuch as in this example the cone-headstock is a very small affair, although fitted with the usual cone and double gearing. The spindle hitherto called the lathe-spindle, upon which the cone-pulley is mounted, is no longer the lathe-spindle, and instead of being raised above the bed, is actually below it. This spindle is in fact continued outwards through the bed, and it is furnished with pinions which drive the two face-plates to which the tires are seen attached. The axle of the face-plate is actually the lathe-spindle, and this is placed in the middle of the bed.

If the lathe were intended to bore tires only, no screw headstock would be needed any more than in the last case, but the two headstocks seen, and which convert the machine into a double complete lathe, are necessary when it is employed in turning the railway axles. The slide-rests are constructed in the ordinary manner, but it will be seen they have very little distance to travel, and the traverse of the tool is effected by a ratchet-wheel and lever. It should be understood that railway wheel-tires are bored out in order that they may be placed upon the central part of the wheel. Generally the wheel is a solid forging or casting, and this is bored out to fit fast upon a wrought iron or steel axle, and the face of the rim of the wheel is also carefully turned up in a suitable lathe to a size determined by a gauge. The tires are sometimes of high class wrought iron and sometimes mild steel. They are now usually made without a weld —that is to say, the iron is rolled whilst hot, and in a suitable machine, into a complete ring of the proper section and size, and in this form and state it comes into the hands of the turner, who has to turn or bore out the inside of the tire to a size *slightly* less than the wheel-blank upon which it is to be fixed, and also to face up one edge of the tire. The difference in size between the wheel and tire is a matter of great importance, but this is not determined by the turner, who has a gauge given him, and to this he must be careful to work. After the tire is bored it and the wheel-blank are taken to the forge, where the former is heated in a clear fire on a special hearth to a very low red heat, or scarcely so hot, but this temperature is sufficient to cause the metal to expand and the ring or tire to become perceptibly larger—large enough, when taken from the fire, to allow of its being slipped upon the previously too large wheel. A little water is now sprinkled over the hot tire, which latter when cooling endeavours to return to its original size, and when cold, if the operation has been properly conducted, the tire is found immovably shrunk on to the wheel.

The first object of the tire-boring lathe will be now seen, but the lathe under notice is also designed for turning up railway axles, an operation which is thus performed:—The wheels being bored out to a certain size, the axles require to be turned down to the same diameter; but the fit of the wheel upon the axle is an extremely tight one. Indeed, it is so much so that hydraulic pressure is now very generally employed to force the wheels on and off their axles. Two necks or bearings have also to be turned in the axles, one at each end, and the extreme ends have to be faced up. All of this work, it will be observed, has to be performed upon the ends of the axles only, and there is no necessity to touch the middle part of them if the rough bar be carefully centered and straightened. If the axles were turned up in an ordinary lathe, the workman would operate upon and probably completely finish one end of the axle at a time, as one end would be required for the lathe-carrier. But as it is not required to turn the middle of the axle, it becomes possible to operate upon both ends simultaneously, provided some means can be devised for driving the axle from the middle instead of from the end. And this is one of the objects of Messrs. Fairbairn

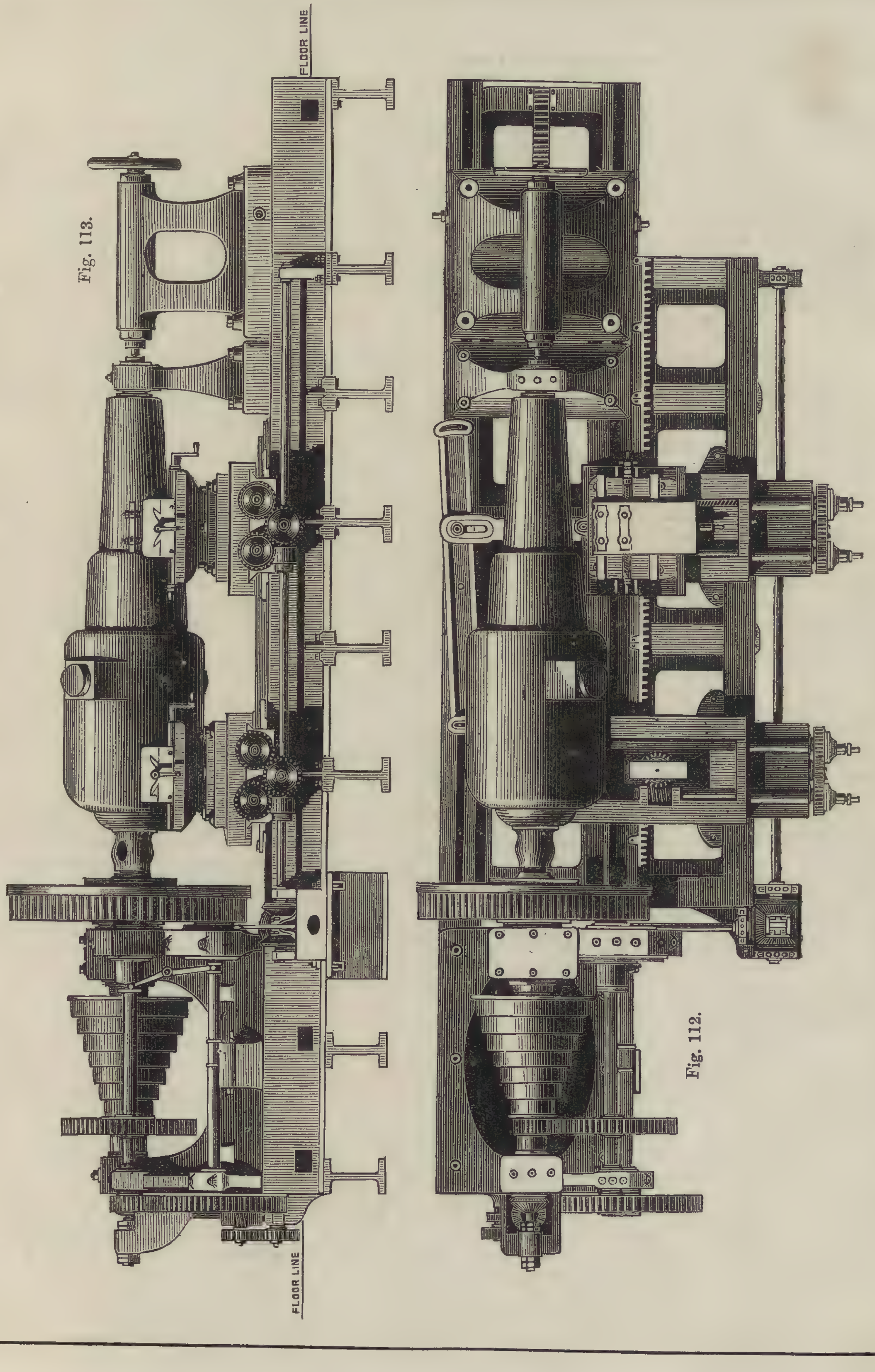


Fig. 112 (PLAN) AND Fig. 113 (ELEVATION).—SPECIAL LATHE IN USE AT WOOLWICH ARSENAL FOR TURNING-UP 600-POUND GUNS.

and Co's lathe. The axle properly centered and straightened is put through the lathe-spindle, or spindle carrying the face-plate, which is made hollow for the purpose, and the ends are supported by the two screw headstock centres. The two slide-rests are then arranged for work, and both ends of the axle are turned at one time. Lathes specially designed for axle-turning alone are also in very general use, but they do not present sufficient interest to require separate illustration. They are constructed very much on the same plan as the combined tire-boring and axle-turning lathe, but it will easily be understood that the machine may be rendered neater, lighter, and altogether better adapted to axle-turning if the tire-boring power were not introduced. When these axles are turned, and the two wheels fitted to them, the complete axle is taken to another lathe in which the flanges and conical treads of the wheels are turned to the required size and form. Railway wheel-turning lathes are very massive machines, in which the axle with its wheels is hung between the centre points of two heavy headstocks, both of which are generally driven, so that instead of driving from one end only, and transmitting the power through the axle itself, each wheel has its own driving-plate and arms which impel it round against its own cut, and without any torsional strain coming upon the axle upon which the wheels are mounted. These lathes are frequently furnished with four complete slide-rests, two of which operate on each wheel, one on each side of the axle. There are thus four tools acting at one time, and the work is turned out with great rapidity. When two tools are employed on opposite sides of the work, one of them has to be placed upside down as it were, because the cut comes to the tool from below, instead of from above as in the ordinary manner. Two tools applied in this way are frequently fitted to ordinary self-acting lathes, and such lathes are then known as "duplex" lathes. The duplex system originated with Mr. Whitworth, and Sir Joseph Whitworth and Co. are still the chief makers of such lathes. The system has been somewhat slow in coming into favour for ordinary work, but its advantages for heavy work are unquestionable, and its adoption for large lathes is consequently more universal.

The special lathes now in use in large engineering and manufacturing establishments form a very large and interesting series of examples of the application and extensive usefulness of the lathe; but it would be foreign to the purpose of the present papers to enter with greater particularity into this large branch of turning. It will be sufficient to conclude the notice of large lathes with a description of one of the finest of its class yet constructed. Several of the lathes shown at Figs. 112 and 113 were designed and constructed at Woolwich Arsenal for turning up 600-pound guns, and they are probably amongst the largest and heaviest in the world, as may be gathered from the following particulars:—The length of the bed is 36 feet, and the width without the saddle-bed 6 feet, with the saddle-bed 10 feet. The height of centres is sufficient to receive a diameter of 8 feet 6 inches; and the diameter of the face-plate is 7 feet 8 inches. All these dimensions are great, but lathes have been constructed with larger beds and also with larger face-plates, although such lathes have been wanting in the solidity and power of the present machines, as will be seen from the total weight of each of them, which is over 84 tons.

The feed is worked off the mandril by direct gearing, and applied to the saddles and rests by means of friction-plates.

The gun is mounted between the headstock in the usual manner, but an extra support is applied to it at the muzzle end. Of the two slide-rests one is employed to produce the conical or tapering parts on the muzzle side of the trunnions, and the other is used in turning the breech. In a previous example of a lathe with apparatus for conical turning, the required movements were obtained from the combined motions of two screw-working slides at right angles to each other; but in the present example the taper is produced by means of an inclined guide placed behind the gun and connected by a link with the slide-rest. The guide may be adjusted to any moderate inclination, and it gives the necessary receding motion as efficiently as the more complicated mechanism.

The size and power of these magnificent lathes can easily be imagined from the dimensions given above, and from a consideration of the enormous bulk and weight of the massive guns that are turned up in them with as much ease as soft wood in an ordinary lathe.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XVII.—SCHOOL MUSEUMS.

THE AIMS OF A SCHOOL MUSEUM IN RELATION TO SCIENCE-TEACHING.

It is no longer desirable to enter on a discussion as to whether science should or should not be taught in schools, for the question has been settled, not by the mere advocacy of men of science, such as Henslow and Huxley, and of practical school instructors, such as Farrar of Marlborough, Hutchinson of Rugby, Griffiths of Harrow, and Tuckwell of Taunton,* but by the result attained at our great public schools, where they have had the courage and means to make the experiment in the proper spirit and on a sufficient scale, hampered as the attempt has been, in many cases, by the opposition of those who had received their education in our ancient universities, in days before their systems of instruction were in the smallest degree leavened by modern innovations, and who had been trained as teachers in institutions which have inherited "an order of tuition some hundred years old, fortified with minute, unbroken, venerable traditions, looked upon for ages past as the supreme instrument and test of intellectual power, whole and complete in itself, supported by immense experience, worked by tried machinery" (Tuckwell).

So intimately is the question of "science-teaching" associated with the requirements of a school museum, that it is, in the first instance, necessary to consider the aims of science-teaching at schools, in contradistinction to the aims of professional scientific instruction at our collegiate institutions.

It seems to me that the manner in which science is at present taught in our public schools, gives evidence of its introduction into the antique curriculum having been effected by the insertion of the thin edge of the wedge, through the accident of one or more of the existing masters having possessed special scientific tastes, at the time when the necessity for science-teaching in schools was first publicly discussed, rather than through the adoption of any well-digested scheme as to what a school course on science should embrace; and this I believe is confessedly the case. It was quite natural that when so important and (to the minds of most of the head masters of former days) questionable an experiment had to be made it should be entrusted to those already conversant with the existing method of the schools, rather than to strangers. In such cases, botany seems to have been the favourite subject for a starting-point, as good diagrams were readily obtainable at a cheap rate, and specimens are attainable in abundance, without cost; while astronomy and elementary mechanics seem to have been the subjects next best suited for amateur science-teaching at the hands of the mathematical masters. Then geography was extended from the old dry groove into its more vitalised physical aspect, so that a certain amount of the natural history of our earth was brought under the notice of the pupils, though in this department there was and still is a deficiency of suitable teaching material for the proper illustration of such an important subject. When the time came for the appointment of properly *trained* scientific men as teachers in our great schools, it is not surprising that, in most cases, the successful candidates proved chemists, as chemistry and mining were the only branches of science that had been taught *practically* in this country; for it is but within the last few years that physical and physiological laboratories have been attached to our recognised seats of scientific instruction, nor were the students of the Royal School of Mines enabled to manipulate physical instruments and carry out biological investigations with their own hands, until a few years ago, when

* Professor Henslow's "Practical Lessons in School Botany;" Professor Huxley's various lectures on science in schools, collected in "Lay Sermons," 2nd edition, 1871; Farrar "On Natural Science Teaching in Public Schools;" British Association, 1866; Hutchinson's "Science Work in Rugby School;" Griffiths' "Report on Natural Science Instruction," British Association Reports, 1868; Tuckwell's "The Method of Teaching Physical Science in Schools," and "The Obstacles to Science Teaching in Schools." Numerous articles on science-teaching in school, at home, and abroad, by various authorities, are scattered through the volumes of *Nature*.

suitable arrangements were provided at the new "Science Schools" at South Kensington. Even in those schools, which are the most advanced as to the method of science-teaching, no complete course on physics has as yet been given, nor has any serious attempt been made to give instruction in mineralogy or zoology, if the returns I have obtained from our public schools are perfectly correct, though human physiology has been, since the publication of Huxley's admirable "Lessons" and Marshall's diagrams, in a few instances taken up.

The most perfect school course on science I am acquainted with is that which was adopted at the Liverpool Collegiate Institution in 1854, by Dr. Birkbeck Nevins and Professor T. C. Archer. It comprised 13 lessons "on the general properties of matter," 6 on "mechanical powers," 16 on "hydrostatics and hydraulics," 10 on "pneumatics," 13 on "heat," 8 on "light," 7 on "magnetism," 11 on "electricity," 9 on "galvanism," 4 on "electro-magnetism," 1 on "thermo-electricity," = 98 lessons on "Natural Philosophy;" and lessons on the most important elements and their compounds and manufactures connected therewith, "chemical philosophy" and practical laboratory instruction to the extent of 100 on "Chemistry," which extended over two years, and were given to the senior pupils of the *classical and modern divisions* that constitute the upper school; 10 lessons on "economic zoology," 10 on "structural botany," 10 on "economic botany," 10 on "economic mineralogy" = 40 lessons on "Natural History in relation to Commerce," extended over one year, were given to the *modern division* of the school. The "classical division" being preparatory to the *universities*, the "modern division" provided a comprehensive education for *business*. Since Professor Archer's appointment to the Edinburgh Museum of Technology, the natural history course has been dropped, and at the present time rudimentary chemistry is taught in the lower school, and chemistry and natural philosophy in the middle and upper schools.

At Cheltenham College science is taught both in the classical and in the military and civil departments, and the entire course comprises botany, geology, physical geography, chemistry, light, heat, electricity, magnetism, pneumatics, hydrostatics, and mechanics. A museum is attached, which is open *one day* in the week to the collegians and one day to the public, and contains collections of mineralogy, botany, entomology, geology, illustrations of arts and manufactures, chemical, physical, and mathematical instruments, ancient and modern coins. At Rugby the course comprises botany, geology, astronomy, physical geography, chemistry, heat, electricity, magnetism, pneumatics, hydrostatics, mechanics, and physiology; instruction in practical chemistry is given in a well-appointed laboratory, "Harcourt and Madan's Practical Chemistry" and "Fresenius" being adopted as the text-books. In connection with this school is an astronomical observatory, wherein is mounted a magnificent equatorial telescope, formerly the property of Mr. Dawes, fitted with an $8\frac{1}{4}$-inch achromatic object-glass by Alvan Clark, which is ultimately to be made the property of the school. This telescope is supplemented by half-a-dozen refractors and reflectors of large size belonging to the staff. A museum has also been established by the Rugby School Natural History Society (founded in 1867), mainly for the purpose of illustrating *local* natural history, which contains good and well-arranged collections of local plants, butterflies, moths, beetles, birds, fossils, etc., collected within a range of five miles radius by the members of this youthful society. This is supplemented by a carefully-selected series of minerals and a complete set of specimens to illustrate Professor Rollerston's "Typical Forms of Animal Life," to which a clear description of every dissection is attached. This society, it may be said to the credit of its members, has published five illustrated annual reports.

At Eton, beyond a little botany, natural history has not yet been attempted, except such as pertains to the subject of physical geography. Astronomy, heat, hydrostatics, mechanics are taught, but the principal subject is chemistry. Practical instruction in a well-appointed laboratory is given out of school hours to those who attend the chemistry course. It is to be regretted that in a school of this standing neither a museum nor a boys' society has, as yet, been established. An observatory has been erected on the roof of the western tower of the new school, in which has been mounted a refracting telescope of 5·9 clear aperture and 88 inches focus, under the superintendence of its makers, Messrs. Cooke, of York. As this instrument was selected especially for the requirements of school instruction in practical astronomy, I may state that an interesting account of the telescope and its appliances is given by Mr. H. G. Madan, the science master at Eton, in *Nature* for January 6, 1870.

At Harrow science-teaching was established in 1865 under the management of Mr. (now Canon) Farrar, and was afterwards under the superintendence of Mr. G. Griffiths. Until, however, a laboratory and museum, and other suitable buildings are erected, real practical work must be of a very limited character. At present three hours in each week are devoted to teaching experimental physics to the "modern side," and one hour in each week to the "classical side" of the school. The boys are required to make copious notes, which are examined and corrected by the master. Those on the modern side are occasionally required to repeat some of the experiments which have been shown during the lectures, and they are examined every fortnight, whilst the boys on the classical side are only examined every term. Comparative anatomy is taught in a practical manner on half-holidays to such boys as voluntarily enter the class. As early as 1864 an interest was manifested in this school for natural history by the publication of a Harrow *Flora*, with notes on birds, insects, etc., and in 1865 the Harrow School Scientific Society was founded, which has printed its reports from time to time.

At Marlborough College, science-teaching has only been in operation since 1870, under the superintendence of Dr. Farrar, late of Harrow. The subjects entered on have been botany, heat, and physiology, and the aim has been to teach each subject thoroughly, with the view of enabling the boys to compete for the science scholarships offered at our universities. As early as 1863, the Marlborough College Natural History Society was founded by the Rev. T. A. Preston, and as its aims and the rules adopted for its management are thoroughly practical, they have served as a guide to other similar school societies since established. This society has formed a museum, containing general collections of minerals, plants, osteological, anatomical, and physiological specimens, lepidoptera, birds and birds' eggs, but aims in future at making the museum more of a local character, when more room can be obtained, as much of its utility is destroyed through its being at present located in one of the class-rooms. This society has published a series of reports.

At Sherborne School they are only getting science-teaching into shape, and are busied in preparing proper buildings for the purpose. Lessons are given regularly in mechanics, geology, and physical geography, and the material for the foundation of a natural history museum has been collected. At the Countess of Harewood's school, near Leeds, Mr. Jones, the head master, taught science in a systematic manner, illustrated by specimens, as early as 1855. The York School, under the management of the Society of Friends, established a natural history society as early as 1834, which has an excellent local museum, regularly publishes its annual reports, and is still in unpretending operation, though it has sent forth many men whose names are now known in science. At present lectures are given once a week on chemistry, physics, physiology, geology, and astronomy to each of the divisions (senior and junior) of the school. Two hours a week are devoted to practical class teaching, recapitulations, and examinations; an astronomical observatory is fitted with a transit instrument and a good $4\frac{1}{2}$-inch equatorial telescope; and a workshop with lathes, fret-cutting machines, benches, tools, etc. Prizes are offered for natural history, "collecting," etc. Occasional lectures are given on general subjects by others than the staff.

At Taunton Collegiate School physical geography, botany, human and comparative physiology, and chemistry are taught. Physics is taught in a well-filled museum, which also serves as a lecture-room; practical chemistry is taught in a small laboratory, mechanics in a workshop, and to aid the practical botany class half an acre of ground is laid out with about 250 plants. In this garden there is an observatory, with a set of meteorological instruments, the records of which are published in the Registrar-General's reports. In this school science is made compulsory on all boys above the lower school, and it takes rank with other school work, and involves no extra charge.

At the City Middle Class School, the first established by the Middle Class Schools Corporation "to provide such an education

as shall prepare the scholar for the industrial and commercial work of life, and such as shall not have the effect of excluding any of the classes for whose benefit the schools are founded," for the almost nominal terms of one guinea per quarter, two or three branches of elementary physics and chemistry are taught in the upper division, together with practical chemistry in the laboratory; but I have not received any detailed statement from this school of the actual work done therein. At present, both lecture-theatre and laboratory are on a small scale, but the head master is seeking subscriptions both from the governors of the Corporation and the parents and friends of the pupils, towards a fund for the erection of, *primarily*, a *large* hall, capable of holding 1,000 adults and 500 boys, wherein the head master and others may, on the occasion of the distribution of prizes and on other contemplated "occasional gatherings of boys' parents and of friends and patrons," be able "to address *all* its numbers assembled;" *secondly*, for the erection of *a small lecture-room*, connected with a laboratory, where 50 boys at a time could study chemistry practically, and another laboratory where physical science could be taught experimentally. In association with such science rooms, *a small museum* is *ultimately* contemplated. Considering that the City Middle Class School will be the model for all other schools, presently to be opened by the Corporation in other parts of London and its suburbs, it is to be regretted that the contemplated *science buildings* have not been considered of *primary* importance, wherein a lecture-theatre capable of holding 1,500 persons would also have met the requirements of the contemplated *occasional* gatherings of masters, pupils, friends, and patrons, and provided a fitting shrine for "that *genius loci*" which should ever be associated with a great public school.

From the examples cited it is evident a great amount of good and earnest science-work is being carried on at the present moment in our public schools, but upon no definite system, with too prominent an absence of instruction in general natural history (an excellent medium for conveying elementary information as to the nature of the objects that surround us on every side, and provide the necessaries for our very existence from day to day) and a deficiency of teaching material—collections of *objects, as belonging to the schools themselves*, being an exception, through too great a reliance being placed on cheap diagrams, which can never take the place of actual specimens, any more than the actual observation of physical phenomena can ever be supplanted by book-knowledge, be descriptions ever so graphic, if instruction in science is intended to stick, as stick it will, and for a life-time, if a teacher will but employ demonstration as well as assertion. There is a vulgar saying that "there is nothing like leather;" well, I fancy those specialists who have been appointed as science masters to our great schools, have, as a rule, put too great a faith in their adopted subjects, and have devoted their energies to making the boys under them expert botanists, chemists, or physicists in some special department, rather than trying to impart that amount of elementary scientific knowledge which *every* educated man should possess—knowledge which could not be designated as "superficial," and which could always be supplemented with a greater or less amount of advanced instruction in such departments of science as would prove of most advantage in the professional future of a boy. This, I think, should be the *primary aim* of science-teaching in schools, as it involves that kind of training of all the senses which, confessedly, neither classical nor mathematical teaching touches—viz., *observation* of objects, phenomena, and the results of experiment, which necessitates the acquisition of that precise *terminology* whereby all observations may be definitely expressed or recorded in a language common to all naturalists, and inculcates a habit of keeping the faculties alive and the eyes open, not merely for the things that lie in our path, but for those that may be hidden in nooks and corners of the earth, under the waters, or in the sky above our heads.* *Comparison* (which Huxley has well defined as "the process of tying up similar facts into bundles, ticketed ready for use," under the name of "general propositions") provides good exercise for the discriminating powers, and lays the basis for a due appreciation of the orderly arrangement of the results of comparison—viz., *classification*, and of methodical description associated therewith, termed *physiography*.

To the inquiry, "What elementary course would provide the amount of information and the kind of training indicated?" I would answer, a complete course on natural history; for does not mineralogy—that much-neglected science in a country abounding with mineral wealth—provide material for instruction in the most important chemical, structural, crystallographic, physical, acoustic, optical, thermotic, electric, magnetic, organoleptic, and crystallogenetic (the equivalent of embryological character in organic nature) characters of inorganic bodies, as a necessary prelude to instruction in the morphological and physiological characters of plants and animals? and, as Huxley says, "systematic teaching in biology cannot be attempted with success until the student has attained to a certain knowledge in physics and chemistry; for though the phenomena of life are dependent neither on physical nor on chemical, but on vital, forces; yet they result in all sorts of physical and chemical changes which can only be judged by their own laws."

* "To a person uninitiated in natural history, his country or sea-side stroll is a walk through a gallery filled with wondrous works of art, *nine-tenths of which have their faces turned to the wall.*" (Huxley's lecture "On the Educational Value of the Natural History Sciences," at St. Martin's Hall, 1854.)

GREAT MANUFACTURES OF LITTLE THINGS.—XVI.

JEWELLERY (*continued from page* 310).

BY CHARLES HIBBS.

The ancient workers in precious metals made indiscriminately jewellery, drinking vessels, candlesticks, reliquaries, statuettes, and all articles of *vertu* in gold or silver, besides ornamenting armour and sinking dies for coins and medals. The minute subdivision of the arts which now prevails was then unknown, and the same Jewish artificer, Bezaleel, who set the twelve stones in the breastplate of judgment, and made the wreathen chains by which it hung, was also competent to work the fine gold threads into the linen of the ephod, and to construct the ark of the covenant and the mercy-seat of pure gold. Benvenuto Cellini made chalices and jewelled clasps for Pope Clement; and the English goldsmiths of the days of King Jamie were ready to turn out a necklace, a pair of earrings, or a service of massy plates, as the humour of their patrons served. The reason was that the processes of working were in all essential respects the same, whether the article were small or great; and even to this day, with all the changes in modes of production, plate-work is but jewellery-work writ large. As regards the *artistic* working of the precious metals, those changes have not been great from the earliest times, and the method followed now differs but little from that of the ancient workmen, who turned out their work by *embossing*.

Sir M. D. Wyatt thus describes the present mode of gold-working:—"Thus prepared"—*i.e.*, rolled into sheet—"the gold is ready for the goldsmith or jeweller, who commences beating it or twisting it into form, according to the nature of the object he would produce. Should he desire to execute embossed work upon it, he first, with a dry point, traces the subject he wishes to represent; then he beats it up, at first with a metal, but subsequently with a wooden hammer, into an approximative form, taking care not to reduce the thickness of the plate too much. He then proceeds to back up the concave side with a composition of pitch, wax, and brickdust melted together (a substance so tough as to be called by the mediæval writers 'tenax'), and upon the surface of the gold, thus equally supported, he continues to beat and punch until the desired relief and form are attained; then, with files, delicate chisels, gravers, and burnishers, he concludes by chasing up the more delicate details, and gets rid of the 'tenax' by heating it, until it runs out in a fluid state."

Compare this with Cellini's own account of the manner in which he worked:—"I will here speak of a gold clasp of a round form, which I made for Pope Clement VII., with which he fastened his mantle, and partly of the manner in which I worked it. . . . . Having made the model of the exact size of the intended work, I took a sheet of gold, larger by a finger all round than it would be when finished, and commenced bulging it in the middle, striking it with small hammers on the face of an anvil; but on the inside I struck it with the point of the

hammer, thus causing it to swell up very much in the middle; and where I observed that it was too thick I worked with the punches on either side, till the principal figure, that of the 'Father,' began to assume a suitable form. In this way, little by little, using all sorts of punches, with patience and enthusiasm, I made the gold plate obedient to me, and in a few days I very nearly got the figure of the 'Father' quite round."

He then describes how he fetched up the figures of the cherubs, "which were in number 15," and gradually detached them and the principal figure from the "field" of his work, bringing them out in entire relief, so that they only touched the groundwork here and there—a feat which the artists of his time delighted in. Thus finished, the clasp, which was only a hand's breadth, must have been a masterpiece of patience and ingenuity, as well as of art. It is much to be lamented that scarcely any of these works have come down to our time; the metal in which they were wrought was too conveniently valuable, and the cupidity or the exigencies of the owners often tempted them to sacrifice the glorious impress of the artist's genius for the sake of the medium that bore it. Clement himself is said to have melted down objects of art to the extent of 200 pounds weight of solid gold.

In the work just quoted from, the "Trattato dell' Oreficeria," Cellini also describes the practice of some of his fellow-artists. Speaking of Caradosso, he says:—"That most worthy artificer made, in the first place, a careful model in wax of his subject, and filling up with clay the under-cuttings, cast it in bronze; he then took a plate of gold, the thickness of which increased towards the centre, not so much, however, that he could not easily bend it, its width being also greater than that of his model. Having heated and worked the plate to a raised form, he placed it on the bronze model, and then hammered it with tools or punches made of birch or wild cherry, gradually causing the plate to take the form of the figures on the model, taking care, however, that the gold should not break, using his tools, whether of iron or wood, with great dexterity on either side of the plate, and always striving to render the gold of an even thickness throughout. The carefulness of Caradosso in this was very great."

The reader must not suppose from these descriptions that the art of metal-working, as practised in the jewellery manufacture of the present day, is of the slow, elaborate, and creative character belonging to the old masters. The plate of gold or other metal is still raised into relief, but it is done with the stamp and die, and the impressions from one design may extend to thousands of grosses. Any visitor to a modern jeweller's workshop, who expected to see the "cunning work" of the Italian artificers carried on in appropriate mystery and secrecy, would be cruelly disenchanted by the great heaps of "blanks," all of one pattern, which he would see lying before each workman, being advanced one little step at a time, with machine-like accuracy and monotony, not dwelt upon separately and lovingly until each became a "thing of beauty" and a "joy for ever." It is possible that these "blanks" (parts of lockets, bracelets, etc.) may be of some design registered by the manufacturer, and struck from his own die; but the greater probability is that they are what the trade calls "parish patterns," made by a jeweller's stamper, who is, perhaps, in a large way of business, employing many hands, and who sells these things to jewellers at so much per gross. The first thing which is likely to strike the visitor is the compact packing of the workmen, who seem almost as close together as soldiers on parade. Each sits down to his work, and the bench or table before him, whose rudimentary outline is half circular, has been scooped out to admit his body, so that he sits half enclosed, and is enabled to dispose his work and tools conveniently round him. In the centre of the hollow is a small wedge-shaped projecting piece of wood, called the "peg," on which he performs all his operations, and beneath is stretched a leather apron, or "skin," to catch the filings, and to serve as a convenient receptacle for tools. A board no larger than a common-sized dressing-table may have three holes, and accommodate as many workers, but some boards have four or five holes. A large shop will have a row of these boards down each side, and a double row in the middle, and thus as many as 100 men may be at work in a single room. In the centre of each board is the gas-jet which gives light to the whole group of workers sitting round it, and close to the right hand of each man is a little bent gas-pipe with open mouth, constantly burning, the flame of which he uses for soldering. The atmosphere of the shop after nightfall is consequently very warm and oppressive, but means are taken in the large and well-regulated factories to ensure good ventilation. Let us suppose that the work under progress is that of making lockets. The workman has a heap of backs, rims, rings, and other parts before him, and taking up a single "back," which in jeweller's parlance means either the top or bottom side of the locket, he fixes on it a rim in no time with a small pair of pliers, plasters round the joint very finely with moistened solder, and dives into the recesses of his skin for the "devil," which is a bunch of matted iron wire. Laying his work in the centre of this, he turns on his soldering-jet to the full, and with a blowpipe directs a stream of flame on to the whole surface, till the locket and the wire are both of a dull red. The two parts are one from that moment, and the metal would break in any other part as soon as in the joint. One half of the backs are fitted with rims just a thought larger in area than the others, in order that they may just wrap over and snap when the locket is closed. When he has provided them all with rims, and joined them together, he may proceed to affix the hinges. A delicate operation this to perform neatly, but his appliances are very complete. He has some lengths of very fine tube lying before him, and a little file, the round edge of which is exactly the size of the tube. He makes a little groove with this on the edge of one side of the locket, just in the centre, between the two halves, cutting through the rim to the substance of the two backs. Then he lays a length of the tube in the hollow, which fits in nicely, and measures off the length he requires, afterwards cutting it off with a fine saw. A piece of steel wire is next threaded through it, and two more cuts of the saw convert it into three pieces in a twinkling. These are again laid in the little groove, the steel wire withdrawn, a touch of solder is given to one side of the middle piece, and to the other side of the two end pieces, the flame is made to sweep over the joint, and all is fast in an instant. The locket is cooled by being turned into a basin of water; a little bit of wire is passed down the tube, cut off, riveted slightly at the two ends, and there is a beautiful neat little hinge, working easily and smoothly, and as close and firm as though it had grown there. All is the work of little more than a minute, and the jeweller's neat way of handling his tools will excite as much admiration as the neatness of his work.

The rings may next be fastened on, a still more simple and speedy operation. A piece of wire has been coiled round a piece of thick iron wire, and the coils cut through longitudinally, thus making a hundred rings at once. The lockets are ranged, a dozen or so at a time, on a slab of pumice-stone, which is to answer the purposes of the "devil." It is of circular form, and has a slightly raised rim all round it. The rings are placed round this rim, and the lockets being laid in the middle so that their ends touch them, the rings, by reason of the slight elevation on which they lie, come just in their proper places. A touch of solder is given to each, and a good blast of the blowpipe solders them all at once. Thenceforth they can be twisted about by the pliers in any direction without coming off.

Some lockets have raised ornaments on the centre, or round the border, in which sometimes stones are set. These are placed on and soldered in the same way, a number at a time. We have seen how Cellini got his *alto relievo;* this is a cheaper way, and good enough for the general market, though not calculated to make a connoisseur fall into raptures. It is in these ornaments that the jeweller finds scope for variety in design, and the plain oval trinket will grow into a Greek, a Byzantine, or an Etruscan, or sometimes into a mixture of all the styles together, in a few seconds.

The processes of making brooches, scarf-pins, bracelets, etc., are precisely similar in character to those described above. The parts are previously prepared by being raised by the stamp, "drawn through" in the manner described of certain articles in cabinet brass-foundry, made into tube, or wire, and bent into shape, the tube being previously filled with solder to prevent its flattening, and afterwards are put together with the handy pliers and the aid of the ever-accommodating "devil." One radical difference exists in the method of joining the parts of plated work, which, as we have explained, is, through every stage of its progress, a thin skin of gold on a body of baser metal. The great heat from the blow-pipe would

infallibly melt off the precious surface, so the makers are fain to be content with using a miniature tinner's soldering iron, and a solder more easily fused. The one method is called *hard* and the other *soft* soldering.

The articles are now polished, which is done by girls at a lathe. The polishing medium is grease, rottenstone, or emery, and rouge; and it is applied by a revolving brush, which finds out all the corners, and does not injure the most delicate parts. Plated work has again to be treated exceptionally, on account of its tender skin; but the metal, which was bright at the commencement, is kept bright throughout, and needs only a rub with the grease-brush to finish it. "Compo" work is of the dull copper colour left by the annealing, and has, besides, a "scale," which it is necessary to take off; some portion of the substance, therefore, is polished away. The metal being of so little value, this is of no consequence; but even if it were gold that was being so operated upon, there would be means of preventing loss. Every scrap of polisher's waste, every grain of shop dust, is religiously preserved in a gold-working establishment for future analysation. The worn-down brushes themselves, the "skins" which have been stretched beneath the boards, the very water in which the men wash their hands, all yield golden results when subjected to the refiner's art.

At different stages at or near completion, according to the nature of their construction, the articles come under the interesting manipulation of the chaser. This workman has the best claim to be called an artist of any that are employed in the manufacture. Something is left to his taste and fancy, and it is his business to put an artistic appearance on the work. For instance, work that has been stamped, however cleanly, will have a blurred roundness of detail, different from the sharpness and crispness produced by the hammer and punch. It will be to real *repoussé* what moulded glass is to cut glass. The business of the chaser, then, is to go over the design with suitable tools, and bring out its features sharply and clearly, as a statue is touched up by the hand of a master after his underlings have brought it into form by almost mechanical means. If the chaser has a real artistic feeling, and knows how to put it into his work, he will give life to the design. Again, it is his duty to enrich the surface of the work with delineated ornament, in which he has some latitude of choice. He requires for his purposes that the work shall be solid, consequently he has to fill the hollow with a composition answering to the "tenax" formerly described, but which is now generally made of a mixture of pitch, beeswax, resin, and plaster of Paris, or emery. When warm this is highly plastic, and can be easily forced into all the interstices, and even when set it is still slightly yielding. When he works with his punches on the surface, therefore, for every depression he makes there is a corresponding rise in the immediate vicinity, and by accommodating his handiwork to this property of the metal, and using a great quantity of punches of various shapes, he gets a slightly raised design. Should he require to raise any part of it still further, he melts out the composition from the under side, and embeds it face downwards, striking up the portion he desires. After he has got the design into sufficient relief, with a sharp and clear outline, he may bring it out with greater distinctness by "matting" the ground. This method, which was well known to the old artists, simply consists in striking the flat surfaces with a roughened punch, the roughness of which has been produced in one of three ways. For coarse or common work, it is sufficient to strike in the ground, flattened end of the instrument a serried rank of small holes with a very fine-pointed punch, afterwards hardening it to suit the work it has to do. A better kind of matting punch is made by *drilling* small holes as closely together as possible into the end, leaving the sharp edges; and some very fine tools of this description are made by the Genevan watchmakers for the use of chasers. The best kind of tool, however, is one the texture of which has been given by nature, and consists simply of a square rod of highly-hardened steel broken off with a sharp blow. Cellini used this kind of instrument; and probably its use would be common among jewellers of the present day, but for the extreme difficulty and rarity of getting a break of the requisite evenness. A workman may break hundreds of punches without getting one to suit him. This operation of "matting," and another which is called "veining," and which consists in indenting fine lines on and between the work, are to the raised design what shading is to a drawing. Much of the so-called chasing on common articles consists in making these linear indentations and impressing upon the work figures of scrolls, foliage, etc., in imitation of engravings. The reason why real engraving is not resorted to is sufficiently obvious. In plated work the thin covering of gold would be cut through at the slightest touch of the graver, and ruined, and for work that has to be gilt after being finished the graver would be useless, since all the effect of the clean sharp cut would be lost in the bath, and the design would look no better than chased imitation, which for such work comes cheaper. When real gold is the metal under hand, however, there is nothing like the graver for surface ornamentation. The best work, therefore, is generally engraved as well as chased.

"Lapping" is an art formerly resorted to a great deal for scarf-pins and other articles in which a solid ball of metal enters into the construction. It consists in grinding the small facets, such as those cut on a diamond to bring up its lustre, and which were cut on the gold for the same reason. It is now principally confined to gold chains, whose appearance it enhances very much. The lapper uses an iron wheel, and works not on the circumference but on the side, which is perfectly flat and true and highly polished. The grinding medium is emery, and the process has nothing in it remarkable, except the great dexterity which the practised workman shows in turning the article about between his fingers, and apparently presenting its surface by haphazard to the stone, at the same time that he is producing the most regular diamond pattern with the accuracy of a machine.

The "setter" is the last workman through whose hands the now resplendent articles pass. He is usually held to be the *crème de la crème* of the trade, as his work requires a special kind of ability which comparatively few workmen acquire. It is possible for every setter to be also a good "maker," but it is not every maker who could become a good setter. His duty is to insert the precious stones, and so to enclose them that they will remain firmly in their settings. There are two systems of setting practised—viz., Roman setting, and what is called colletting. The last appears the most simple. Little fangs or lips are left in the metal, and the gem being inserted between them, they are bent over so as to enfold it, as a rosebud is encircled by its leaves, the effect being often very beautiful. The first method consists in scooping out a small recess, or deepening a recess formerly made by the stamp, in which the stone just fits, and with very fine tools, first making a shoulder for it to rest upon, and afterwards scraping down a portion of the metal to form a lip to hold it in its place, in such a way that the manner of its detention shall be concealed. To give some idea of the extreme delicacy sometimes required in the art of gem-setting, we have but to refer to some specimens of jewellery exhibited by our tasteful neighbours in the World's Fair of 1867. One was a miniature imitation of a tulip, the streaks of colour being obtained by massing rubies, emeralds, and sapphires, and the whole of the remainder encrusted with brilliants and rose diamonds. Another was a tiny peacock, with outspread tail, each eye of the feathers being an emerald, the plumage of the breast composed also of emeralds, and the rest of the body covered with rose diamonds. Lyre-birds and humming-birds there were also, the brilliant plumage of which consisted of stones arranged according to their colours, after nature, shading off till the various tints seemed to blend into each other, and the nodding plumes sparkling with thousands of diamonds. With this glimpse of Arabian-Night magnificence we cannot do better than close our chapter on modern jewellery.

FARMING AND FARMING ECONOMY.

By Professor Wrightson, Royal Agricultural College, Cirencester.

XXI.—SWINE.

ORIGIN—SPECIES—BREEDS—MANAGEMENT—FATTENING—BACON-CURING.

The many breeds of swine found in this country have originated from two species, one of which is still found wild. Although Mr. Sidney throws doubt upon the relation of the domestic hog to the wild boar of European forests, there is great unanimity among naturalists as to his having been descended from that

widely scattered species. It must be remembered that *Sus scrofa* varies much in type with his geographical position, the German boars being very different from those found in India; and it has further been shown that the domestic breeds in these two distant regions exhibit corresponding differences with their wild prototypes. So different, indeed, are the wild boars of one part of the world from those of another, that some naturalists have classed them as specifically distinct. The many breeds of swine have recently been very carefully studied by Hermann von Nathusius, who divides all known varieties into two groups, the one descended from *Sus scrofa*, and the other from *Sus Indica*, or the domestic pig of China, Cochin China, and Siam, an animal which does not exist in a wild state. The *Sus scrofa* breeds constitute the unimproved races of Central and Northern Europe, and Britain, while the Neapolitan, Andalusian, Hungarian, and other breeds of South-eastern Europe and Turkey, have been in a great measure derived from *Sus Indica*.

We may then, without further comment, assume that *Sus scrofa* and *Sus Indica* are the types from which all domesticated breeds of swine have sprung, and that in our country the original *Sus scrofa* type has been greatly modified and improved with the more highly artificial *Indica*.

Mr. Rowlandson, writing upon the breeding and management of swine, says, "There are good grounds for supposing that the old English hog with 'flop' ears was originally the only domesticated animal of its kind throughout the kingdom," and that the improved black and white races are the result of crossing the established and original breed with Neapolitan and black and white Chinese swine, and Chinese crosses. Varieties and sub-varieties abound in every country, so numerously, indeed, as to make it difficult to trace or even distinguish them, a fact which is plainly enough indicated by the rough and ready method of classification adopted by the Royal and other Agricultural Societies, into large, small, black, and white races. White pigs are best seen in the prevalent breeds of Cumberland, Yorkshire, Lincolnshire, and Leicestershire; while black pigs are found in Berks, Hants, Dorset, Devon, Sussex, and Essex. All have been improved by alliance with *Sus Indica*, as already explained. The improved white races are divided, according to size, into large, medium, and small breeds. All may be generally spoken of as prick-eared, short-limbed, fine-boned, white-fleshed, very early in arriving at maturity, and rapid in laying on flesh. The face is generally broad, and the short nose is often almost hidden in the cheeks and overhanging forehead or crest.

The most distinctive black races are those of Berkshire and Essex, and besides these, Hants, Wilts, Dorset, and Devon each possess recognised varieties.

The Berkshire may be thus described:—The head must be short; the features wide; the snout upturned; the forehead concave; the crest overhanging the forehead; ears set rather forward, and slightly drooping over the eye; cheeks well developed; no hollow between cheeks and neck; the neck gradually thickening towards shoulders, and passing into a bold crest on the upper side towards the ears and head; shoulders wide over the top, thick through the blades, and deep, giving a good foreham; the ribs must be well "sprung" from the spine, well arched, and so formed as to give a deep side; the hips wide and level with the back; the quarters straight, "well carried out," and not drooping; the ham well filled, both inside and out, and the gammon resting on the hock, forming with the leg and foot an inverted figure 5; the belly-line close to the ground; the whole animal presenting a square, massive appearance, bounded by a gently curving line from crown to tail, and a carcase showing as little daylight under it as possible. The skin is covered with a moderate coating of hair or bristles, is black with a blush of red showing through the more sombre tint, and broken with white upon the face, feet, and the end of the tail. A general levelness of form, without patchiness and hollows, appears to be, in general language, what is aimed at by improvers of this breed. The average weight of a Berkshire bacon hog fit to kill will be at eleven months old about 20 scores, but the best quality of bacon is obtained from 9 to 14 score pigs.

The improved Essex breed was brought out by the late Lord Western and the late Mr. Fisher Hobbs. Lord Western, "while travelling in Italy (making the grand tour), observed, admired, and secured, a male and female of the breed called Neapolitan, found in its greatest purity, according to a letter addressed by him to Earl Spencer, in the beautiful peninsula between the Bay of Naples and the Bay of Salerno. From this pair Lord Western bred in and in until the breed became deteriorated. These, crossed with the then Essex, and probably the Sussex and Berkshire races, gave the material upon which Mr. Fisher Hobbs, of Boxted Lodge, worked, until at length the improved Essex was the result. These pigs are characterised by their fineness of snout, their uniform black colour, and a greater lightness of form than is seen in the case of the improved Berkshire race. The defect of the improved Essex is a certain delicacy, probably arising from their southern descent, and an excessive aptitude to fatten, which, unless carefully counteracted by exercise and diet, often diminishes the fertility of the sows, and causes difficulty in rearing the young" (Sidney).

We shall not describe any other of the black races, as they so closely resemble either the Berkshire or Essex type that no adequate idea of the minute differences existing can be given on paper. There is, however, a breed known as the Tamworth, of red colour and large size, but not likely to extend, as it is slow in fattening. It is probably closely allied to the Berkshires, as it is apt, when not finely bred, to throw pigs with more or less red colour, mixed with black. The "wattles," or skinny appendages situated upon either side and below the cheek, are very singular, and are associated with some of our unimproved races.

We do not intend to enter at length into breeding and management. Much might be written upon it, but practical knowledge and experience are so essential that we doubt the advisability of giving minute directions regarding matters which must be seen and worked upon in order to be appreciated. It is, however, a golden maxim to breed from parents which themselves inherit valuable qualities, only let us see that such qualities exhibit themselves palpably in the animals used for breeding purposes, and do not (as might be supposed) lie latent in the blood. Again, in-and-in breeding, or the breeding from animals closely related to each other, is found to be practically fatal to success in pig-breeding: this statement might be supported by many examples, and is believed by every pig-breeder.

Perhaps no one has given a clearer statement upon the management of swine, or based his observations upon a longer and more successful experience, than Mr. Stearn of Suffolk. In a lecture very recently delivered, he informed his hearers that the profit or loss upon pigs depended upon the quality of the stock; that in breeding, the parents should be carefully selected; that the sow should be not less than ten to twelve months old, and the boar from eight to twelve months old, when first used for breeding purposes; that two good litters are as much as we should look for from a sow in one year; that cleanliness should be secured by properly constructed piggeries and by continuous care, and frequent *washings of the piggery floor*. Mr. Stearn also gives a detailed account as to his method of treating farrowing sows, which is too lengthy for insertion or even abridgment. The matter is, however, simple, and if a breeding sow is allowed a fair amount of exercise in a grass field, and a well-constructed sty scantily supplied with short straw for bedding, at the time of farrowing she will probably bring a healthy litter. The extreme watchfulness and numerous precautions recommended by Mr. Stearn are not practised by most pig-breeders, and it is questionable whether they are either necessary or advisable. With reference to the management of young pigs, we quote Mr. Stearn at length: "I begin to feed the young pigs at five or six days old with warm milk mixed with a little very fine sharps, and a small quantity of whole maize. For the first few weeks after being weaned, I have the boy feed them very often, but give them a very little food at a time. In the winter I feed all on warm food, but not in the summer. I give them a great variety of meal, such as wheat, maize, barley, oats, and whatever is most convenient to mix it together. I just wet it with cold water, and then scald it with boiling water and sprinkle it with salt; between meals I give them whole maize, and mangold-wurzel, or swedes cut small; and once or twice a day a little coal. I allow them plenty of clean water, and there is one thing I am very particular about, not to give them any more food than they will clear up at a time. When pigs are put to fattening it will be found very beneficial to wash them at least once a week: this is quickly done by experienced hands, and will amply repay any one for the trouble. I also like to have them very often brushed."

Every cottager understands how to fatten a pig. In a word, plenty of barley-meal given of the proper consistency, and regularly, will soon effect this in the case of well-bred swine. Why, then, should we prolong our remarks on a point which is confessedly so simple? Messrs. Lawes and Gilbert, some years ago, undertook an elaborate series of experiments upon pig-feeding, and although the results may have little effect in guiding the practice of cottagers and farmers, yet they at least confirm what has been hitherto considered as good practice, and throw light on the entire subject. The objects of these experiments, the results of which were contributed to the fourteenth volume of the Royal Agricultural Society's *Journal*, were as follow:—

1st. To find the amount of increase from a given amount of food.

2nd. The most desirable proportion of the highly nitrogenous foods to those which are not nitrogenous.

BOAR AND SOW OF THE IMPROVED ESSEX BREED.

3rd. To ascertain within what limits this proportion might be varied, so as to improve the quality of the manure, consistently with economy.

The practical facts adduced from the experiments of Messrs. Lawes and Gilbert were:—

1st. That pigs of about nine months old consume from 29 to 30 lbs. of fresh corn per head per week, and increase in weight at the rate of from 18½ to 21 lbs. per every 100 lbs. of such food consumed.

2nd. That pigs, like sheep and cattle, do not pay for their food in flesh alone, but the profit must be looked for in meat and manure.

3rd. That when pigs had a choice of diet, they preferred nitrogenous food in the earlier stage, but became more attached to the farinaceous diet as they progressed.

4th. That although bran may be useful in small quantities, it is not to be used as a basis of diet.

5th. That farinaceous foods are the best, subject, of course, to the markets.

Bacon may either be salted on a small scale at home, or in "factories," where several hundreds of swine are slaughtered in a single week, and where the curing proceeds both summer and winter with the help of ice-cooled, underground houses. The following is a very brief account of a bacon-factory, where about one hundred and fifty pigs are killed per week:—The pigs are drawn from the sty, where they have been previously awaiting their execution, by means of a chain attached to one hind foot, and are lifted by a hoist, until the nose is about eighteen inches above a grating. The chain now catches by means of a hook upon an overhead rail, which passes, with a slight downward inclination, into capacious sheds. The pig is bled, and the carcase is slid along the guideway just spoken of, until it reaches an apparatus for burning or singeing; the carcase is again pushed forward to a point where it is washed with a jet of water from a hose. Again it is passed onward into the sheds, cut down the back to facilitate cooling, and it is there rapidly joined by other carcases, until the work of slaughter is complete. Subsequently, the back-bones, heads, and blades are removed with great dexterity. The sides, when cool, are taken to the salting cellars, and placed on the floor skin-side downwards. The sides are covered with salt, laid on and brushed in, and remain in that position three days. At the end of this period the salt is brushed off, and the sides are "stacked" for ten days, new salt being freely sprinkled over and between them. At the end of the first week, after killing, the sides are re-stacked and salted, and at the close of the second week they are again stacked and remain until the end of the third week. They are now "green bacon," and only require drying and smoking. The smoking is conducted in a high, flagged chamber, in which oak sawdust is smouldering. The sides and hams are powdered over with pea-meal, and are then hung in the smoke for three days, the whole period from slaughtering to the completion of the curing being twenty-four days. The lard is melted and run into bladders, each pig furnishing a receptacle for his own fat: fourteen pounds of lard will be yielded by a good pig.

MINING AND QUARRYING.—XXXVIII.

BY GEORGE GLADSTONE, F.C.S.

SALT (*continued*).

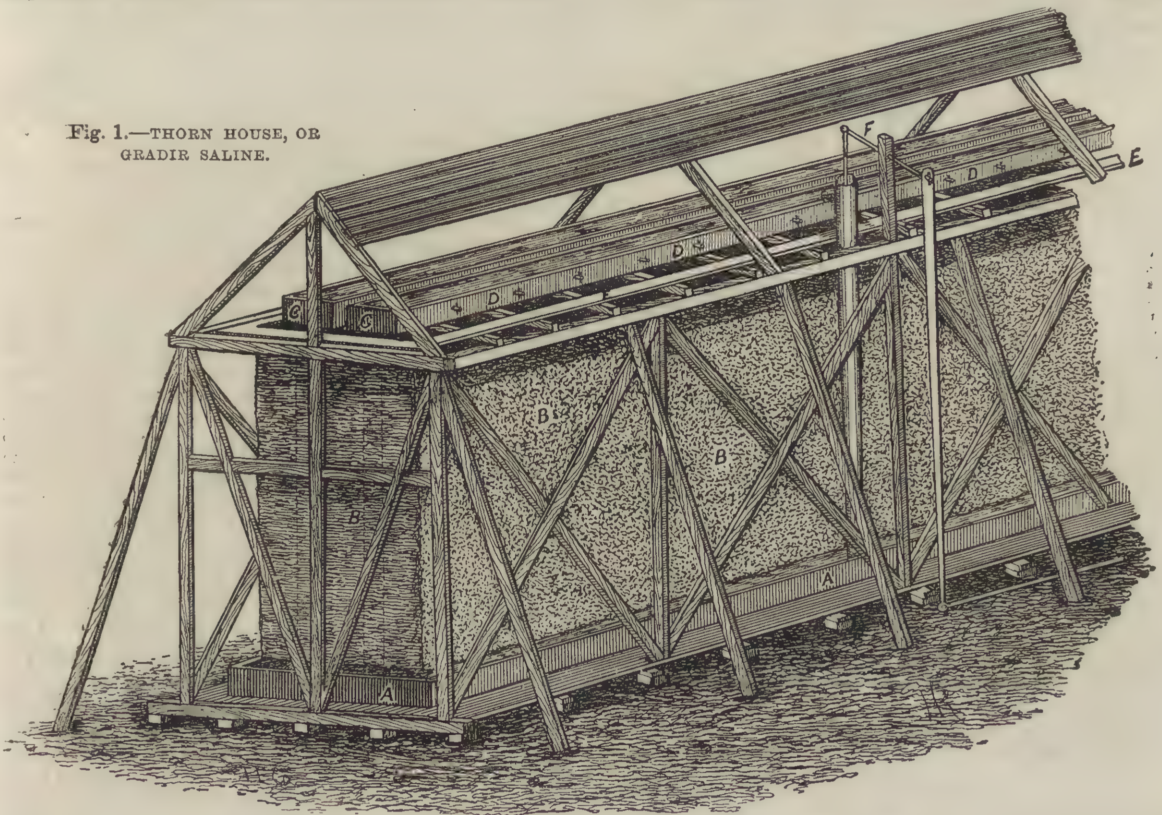
GRADIR SALINEN—CRYSTALLISATION OF SALT—ANALYSIS OF DIFFERENT KINDS—OF PAN SCRATCH AND MOTHER LIQUORS—PHYSICAL PROPERTIES OF SALT—USES—EXTENT OF TRADE.

In the first article on salt, it was mentioned that many brine-springs of the weaker class, which are very common in Germany, are utilised, though they do not contain a sufficient percentage of salt to enable the English plan to be used, and the climate will not admit of its being concentrated in salterns. The system adopted at Sulza, Münster am Stein, Dürrenberg, and other places, depends upon exposing the greatest possible surface of the water under circumstances most favourable to evaporation, whenever the state of the atmosphere is suitable.

by a water-wheel. The troughs have taps, D, D, inserted along their whole length at short intervals, and on both sides; and from these the brine is allowed to run gently, so that it may become broken into drops by the bushes, and trickle through them to the tank below. According to the direction of the wind at the time, the one or the other trough is supplied with the water, and, except when the wind is very high, the outside series of taps are turned on, which direct the little streams to the outer edge of the thorn wall. A platform E runs all along the top, for the man to walk upon who attends to the turning off and on of the taps. The first pump raises the water from the spring to the top of the first compartment, the second that which has collected in the first tank to the troughs of the second compartment, and so on to the end of the series, the contents of the last tank being drawn off into reservoirs to await the final operation.

On the Continent the weather is sufficiently dry and warm to

Fig. 1.—THORN HOUSE, OR GRADIR SALINE.



For this purpose thorn houses, or, as they are called in Germany, *gradir salinen*, are erected in such a position as to be most exposed to the prevailing wind. These are gigantic erections, consisting of a skeleton of timber filled in with thorn bushes, having pumps for raising the water to the top, and a series of pipes and taps from which the water trickles down over the ends of the twigs to the cisterns below. The arrangement will be better understood by reference to the accompanying diagram, which represents the end of one of these long erections. The essential parts of the structure are distinguished by lettering; the great beams which form the framework of the whole will need no explanation. A A is a large shallow tank, extending along the whole length of the *gradir saline*, but divided into three, four or more compartments, which have no direct communication with one another. These tanks receive the drips from above. Immediately above the tanks are the thorn bushes B B, closely and evenly packed, so that their ends form a regular wall, only slightly tapering inwards as it rises. These are surmounted by a platform, upon which rest the two troughs C C, which are also divided into compartments corresponding to those of the tanks below. The brine is pumped up into these by lift-pumps, one of which is seen at F, worked

enable the work to proceed during about two-thirds of the year, and it is done at a minimum of expense, as water-power is sufficient, and but little personal attention is required. During these artificial showers a great deal of water is carried off by evaporation, the brine therefore becoming stronger each time, until at last it contains about 22 or 23 per cent. of salt. In passing through the *gradir saline* another object is attained besides the concentration of the brine; for the oxide of iron, sulphate of lime, and other salts, which are less soluble than the chloride of sodium, become deposited as an incrustation upon the twigs, and the greater portion of these objectionable constituents are thus got rid of. The thorn stacks have to be replaced every few years, the length of time which they last depending very much on the quantity of these salts which the waters may contain. In some places the brine is allowed to trickle slowly over a roof laid upon a very gentle incline, and painted black; but this is only available when the weather is hot, and the sun is shining brilliantly. The concentrated brine is finally evaporated down by artificial heat in salt-pans such as that described in the last article.

Chloride of sodium crystallises in the form of a cube, and if the process of crystallisation is allowed to go on slowly, and at

a low temperature, a series of small cubes are built up one upon another until one of considerable size is the result; the increase takes place first along the edges of the primary crystal, and then the intermediate spaces get filled in, which makes it a solid. If, however, the evaporation of the brine is conducted rapidly, as in the making of fine salt, the surface of the liquor furnishes crystals of an apparently different construction, for the fresh crystals form on the upper edges of the primary one too quickly to allow of the intermediate spaces getting filled up, and so the aggregation takes the form of a hollow inverted pyramid, which floats upon the surface of the brine: it is actually the mere skeleton of the upper face of the cube.

Picked specimens of rock salt may be obtained absolutely pure; but the commercial article made from brine is never quite free from admixture with other ingredients. Of the following analyses the first four are of rock salt, the fifth is a volcanic sublimate, the sixth is the natural deposit at the bottom of the lake, and the rest are manufactured.

	Wieliczka, Poland.	Berchtesgaden, Germany.	Hall, Tyrol.	Cheshire.	Vesuvius.	Elton Lake, Russia.	Cheshire Stoved Salt.	Trapani Sea Salt.	Great Salt Lake, America.
Chloride of sodium. .	100·00	99·928	99·43	98·30	62·45	98·79	98·250	98 94	97·99
Chloride of potassium.	—	—	—	—	37·55	0·04	—	—	—
Chloride of calcium .	—	—	0 25	—	—	—	0·025	—	0·43
Chloride of magnesium	trace	0·072	0·12	0·05	—	0·13	0·075	0·16	0·24
Sulphate of lime . . .	—	—	0·20	1·65	—	1·04	1·550	0·46	1·34
Sulphate of magnesia .	—	—	—	—	—	—	—	0·44	—
	100·00	100·000	100·00	100·00	100·00	100·00	99·900	100·00	100·00

The Vesuvian salt will be seen to be remarkable for the presence of a large quantity of potassium; and it will be noticed that the sea-salt contains much more magnesium than any of the other specimens.

It will be understood from what has gone before that the salt water, whether obtained from the sea or from brine springs, contains much other mineral matter which will not be found in the salt made from these sources; some of the more insoluble of these go to form the "pan scratch" of the English salt-pans, or the incrustations on the thorn bushes of the German *gradir salinen*, while the deliquescent and non-crystallisable ingredients constitute the mother liquors of the evaporating houses, and the bitterns which drain from the stacks of sea-salt in the salterns. These are sometimes turned to advantage in the making of Epsom salts, in the glass manufacture, and for other purposes.

A sample of pan scratch has been found on analysis to consist of the following :—

Chloride of sodium	8·33
Carbonate of lime	12·50
Sulphate of lime	79·17
	100·00

but, of course, being only a refuse product, it will vary in different localities.

The same remark will likewise apply to the mother liquors. We will take as a specimen that analysed by Professor Bunsen of Heidelberg, which was obtained from the graduation works of Münster am Stein. The liquor contained 40·98 per cent. of solid matter to 59·02 of water. The solid contents were in the following proportion :—

Chloride of calcium	81·09
" magnesium	7·93
" strontium	0·70
" sodium	0·84
" potassium	4·20
Bromide of potassium	1·68
Iodide of potassium	0·02
Chloride of lithium	3·54
	100·00

together with traces of the chlorides of cæsium and rubidium; the presence of these last very rare metals is a peculiarity of this particular spring, and they are not found in other mother liquors. The very small quantity of chloride of sodium shows that in this case the common salt, which formed 79·5 per cent. of the solid constituents of the water as it rises from the spring, had been very effectually separated.

The specific gravity of rock salt is 2·13; and it possesses, in a remarkable degree, the property of allowing the passage of the heat rays, 92 per cent. being transmitted by clear rock salt, while only 24 pass through plate glass.

The uses of salt are very various. As an article of food it is not only agreeable as a condiment, but it is almost indispensable for the proper supply of the animal system; so much is this the case, that travellers in regions where salt is wanting describe it as a serious deprivation, and amongst some of the tribes of the interior of Africa it is regarded as one of the most precious substances. In the human system part of it becomes converted into soda and free hydrochloric acid, in which conditions, as well as in its original combination, it exercises important functions. Most animals, besides man, require a certain quantity of it, and lumps of rock salt are often given with advantage to the domestic animals, that they may lick them.

It is largely employed in the preservation of animal substances for future use as articles of food. Both meat and fish are thus cured. The former is effected by immersing the meat in a solution of salt or pickle, and keeping it thus excluded from the action of the air, a strong brine not being liable to absorb oxygen from the atmosphere as water does.

Fish is usually packed closely in casks alternately with layers of salt; the liquor from the fish partially dissolves the salt, and forms a brine in which this article of food is similarly preserved in a moist state; in this case it is found desirable to use the coarse-grained salt, as the crystals being solid are much harder, and dissolve more slowly than the finer varieties. In Norway, Newfoundland, and other places where the curing of fish is carried on upon a very extensive scale, the sea-salt made on the coast of Portugal, and on the shores of the Mediterranean, is principally employed on the score of cheapness; but English salt, if crystallised slowly at a low temperature, so as to form equally large crystals, is at least as good, and perhaps better for the purpose, as the sea-salt always contains more chloride of magnesium, which being hygroscopic, is anything but beneficial. The effect of the salt being to extract a portion of the liquids, the fish can be the more readily cured dry after having been exposed to this preliminary salting; and dried cod and haddock are too familiarly known to need any description.

Passing from the curing of meat and fish, we may proceed to that of timber. One of the most terrible enemies which the shipowner has to fear is the dry rot. It seems to be a kind of fungoid disease of a very spreading character, and which especially develops itself wherever deprived of a free circulation of air, so that the better constructed a ship is, the more liable is she to this affection. It was found that the timber of sunken vessels, however long they may have been submerged, never suffered in this respect; and the experiment being tried of soaking in sea-water the timber which was to be used in shipbuilding, such timber was found to be free from infection. It was found, however, very difficult to keep such vessels dry; and the constant tendency of such prepared timber to absorb moisture exercised a very injurious effect upon the iron bolts employed to fasten the timbers together. This was caused by the presence of magnesium salts in the sea-water, and a solution of rock salt is therefore now used in preference in the construction of the highest classed wooden ships. In America and other countries, where less care is exercised in their construction, it is very common for the shipowners to take a cargo of salt on board, on their first return voyage from England, just for the sake of giving the vessel a little seasoning.

In dyeing, salt is occasionally used, especially in producing scarlet, as it has the effect of heightening the colour of cochineal; but it is to the chemical manufacturer that this mineral is of the greatest value. In Article XXXIV. (p. 225), when describing the production of chlorine gas by the aid of manganese, for the making of bleaching-powder, we have spoken of the use of common salt as the source of the chlorine. The salt used in this manufacture principally comes from Cheshire.

Besides this, salt is the foundation upon which the whole alkali trade is built. It includes the manufacture of soda ash and crystals (two forms of the carbonate), caustic soda, the bi-carbonate, sulphate, sulphite, and others. The processes to which the salt is subjected have already been described in "Chemistry applied to the Arts," No. VII. (Vol. I., p. 330); but it is worth while giving some idea of the quantity of chloride of sodium which is needed to supply the common element in all these compounds. The quantity consumed annually by the manufacturers in the Tyne district alone was computed in 1863 at 90,000 tons; and in the whole kingdom 254,600 tons were converted into alkali during the previous year.

The total produce of the salt mines of the United Kingdom may be set down in round numbers at 1,500,000 tons. Of this about one-half is exported to our colonies and to foreign countries, the remainder being used at home. The domestic consumption has been estimated by statisticians at twenty-two pounds per head, which, for a population of 31,465,480, according to the last census, will amount to 309,036 tons, leaving nearly 450,000 tons for the various purposes of trade, the principal of which are the manufactures of soda and bleaching-powder, and the salting of fish and provisions.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXIX.—PROFESSOR SIR CHARLES WHEATSTONE (*continued*).

In our last paper we brought under the notice of the reader a general sketch of the present system of telegraphy for the million, by Professor Wheatstone's new scheme; and evidence of its general popularity may be gathered from the good-natured readiness with which householders have permitted the posts to be erected on the roofs of their dwellings. To Professor Wheatstone electric telegraphy owes much. With his improved automatic instrument, 1867, properly manipulated, can be transmitted six hundred distinctly visible signs or letters in a minute.

Subjoined are a few of our inventor's miscellaneous contributions to science:—

In 1836 Professor Wheatstone constructed an instrument composed of a sound-box, with a bellows attached to one end, the other the frustrum of a cone with the base outside, and keys inside the box, to the other end. By pressing the wind through the bellows, and fingering the keys with one hand, the other being applied to the end of the frustrum of the cone, the machine will utter intelligibly the words "papa," "mamma," "thumb," "plum."

In 1856, at the Royal Institution, the instantaneous duration of an electric spark, and the means ingeniously constructed by Professor Wheatstone to measure it, were illustrated by the original apparatus employed by the inventor, from which it was ascertained that the duration of a spark does not exceed the twenty-five thousandth part of a second. A cannon-ball, if illumined in its flight by a flash of lightning, would, in consequence of the momentary duration of the light, appear to be stationary; and even the wings of an insect that move ten thousand times in a second, would seem at rest.

Professor Wheatstone's new printing telegraph is so constructed that the message is sent by means of a perforated strip of paper, the holes in which, representing the letters, are made by means of a separate machine, worked by a finger-board. The advantage of this method is, that several persons can work at the finger-boards, and prepare several messages at once; and on the perforated paper being put into the telegraphing machine, it forwards the message at the rate of 500 letters per minute, being about five times faster than the former system. On its arrival at its destination, the message is again pricked off on a paper tape at the same rate, when it can be easily and rapidly read. Another advantage is, that the whole apparatus only occupies a few inches square, there being no battery required, as it is worked by magnetic electricity.

Professor Wheatstone's universal and military telegraph is especially adapted for rifle and field practice. This is a portable apparatus, also worked by magnetic power. It is extremely light, being only six inches square, and is at all times ready for immediate use, without previous preparation. The communication in the field, or between the target and the gun, is maintained in the ordinary alphabetical language by the most simple means, so that any person who can read and spell is able to work it. The communicating wire is covered with rope, and is effectually protected from abrasion or pressure when lying on the ground, though of comparatively small thickness, and when not in use it can be rolled on a drum. This telegraph is now in use in various public offices. Although small, messages are forwarded by it to a distance of twenty miles, but by increasing the size of the magnet much greater power can be obtained. In order to increase the number of messages which could be sent through the wires, in a given time, a very large use has been made of Wheatstone's automatic instruments. Fifteen circuits have been supplied with this apparatus. There are also circuits for ordinary work. The news is sent to all these places simultaneously, and at the rate of fifty to fifty-five words in a minute.

Professor Wheatstone's automatic or fast-speed telegraph consists of three parts—the perforator, the transmitter, and the receptor. The perforator consists of an iron case with three keys, which are struck down by the operator. These keys work three punches, which produce holes corresponding to dots, dashes, and spaces in the paper strip. The transmitter consists of clockwork which draws the prepared paper forward with a continuous motion by the teeth upon the periphery of a spur-wheel entering the central line of holes in the paper. The holes on the one side or the other represent the positions of positive or negative currents. There are two small vertical pins which move up and down underneath the paper strip, one under one row of holes, the other under the other row. When a hole occurs, the pin rises through it, and allows the lever to which it is fixed to oscillate far enough to make suitable contact with the battery. When, however, no hole occurs, the pin is stopped against the paper, and no contact is given. The receptor is somewhat similar to an ordinary ink-recording Morse apparatus. It is somewhat finer in the arrangement of its parts and the various moving portions, a principle upon which, no doubt, the great success of sensibility and fast working depends.

A very powerful thermo-electric battery has been constructed by Professor Wheatstone. It consists of sixty pairs of small bars, and its electro-motive force is said to be about equal to two of Daniell's cells. "On connecting the terminals of this battery, excited as Marcus's, a brilliant spark was obtained, and about half an inch of fine platinum wire, when interposed, was raised to incandescence and fused; water was decomposed, and a penny was electro-plated with silver in a few seconds; whilst an electro-magnet was made to lift upwards of a hundredweight and a half. Bright sparks were obtained from the primary and secondary terminals of a Ruhmkorff's coil connected with the battery. In fact, all the effects obtained from a small voltaic combination were reproduced with ease by this thermo-electric battery." In constructing this battery, Professor Wheatstone found confirmation of the curious fact announced by Marcus, that the power of a battery of this kind is very greatly increased by frequently re-melting the alloys of which its elements are composed. This is supposed to be due to the repeated fusion breaking down the crystalline structure of the alloys.

In Wheatstone's electro-magnetic clock, the object is to enable a simple clock to indicate exactly the same time in as many different places distant from each other as may be required. A standard clock in an observatory, for example, would thus keep in order another clock in each apartment, and that with such accuracy, that *all of them, however numerous, will beat dead seconds audibly with as great precision as the standard astronomical time-piece with which they are connected.* But, besides this, the subordinate time-pieces thus regulated require none of the mechanism for maintaining or regulating the power. They consist simply of a face, with its second, minute, and hour hands, and a train of wheels which communicate motion from the action of the second-hand to that of the hour-hand, in the same manner as an ordinary clock-train. Nor is this invention confined to observatories and large establishments. The great horologe of St. Paul's might, by a suitable network of wires, or even by the existing metallic pipe-works of the metropolis, be made to command and regulate all the other steeple-clocks in the City, and even every clock within the precincts of its metallic bounds. As railways and telegraphs extend from London nearly to the remotest cities and villages, the sensation of time may be transmitted along with the elements of language; and the great cerebellum of the metropolis may thus regulate by its power, the whole nervous system of the empire.

Thirty years from the date of his invention of the electric telegraph, Professor Wheatstone received the honour of knighthood. It must not, however, be supposed that such distinction has been earned by the above invention alone. The President of the Italian Scientific Society of Forty, in presenting to Sir Charles Wheatstone the gold medal awarded to him in place of the late Professor Faraday, said: "I cannot refrain from calling to mind that to you, Sir Charles, we owe the discovery of the method, as ingenious as it is original, for measuring the velocity of electric currents, and the duration of the spark. The applications of the principle of the rotating mirror are important and various. Not less is the invention of the stereoscope, and of the modes by which binocular vision is effected, which enables us to obtain the perception of the relief from simultaneous observation of two plane images. Also, the memoir on the measure of electric currents, and all questions which relate thereto. All physicists know how many researches have since been undertaken with your rheostat, and with the Wheatstone's bridge; and how usefully these instruments have been applied to the measurement of electric currents, of the resistance of circuits, and of electro-motive forces. To you we principally owe the practical invention and true realisation of the electric telegraph. Finally, I would call to mind your recent researches on the augmentation of the force of a magnet by the reaction which its own induced currents exert upon it."

Professor Wheatstone, D.C.L., LL.D., F.R.S., was a Corresponding Member of the Academies of Science of Paris, Brussels, Berlin, Munich, Stockholm, Turin, Milan, Rome, Washington, etc., and Chevalier of the Legion of Honour. He died Oct., 1875.

COTTON-SPINNING.—IV.

By J. Robertson.

THE FLY-FRAME.

The fly-frame reduces the sliver produced by the drawing-frame, and at the same time imparts a slight degree of twist for the purpose of strengthening it. Two, three, and sometimes four of these machines are used in succession. The most approved system, except where very coarse or very fine numbers are being spun, is to have three, called respectively slubbing, intermediate, and finishing frames. The mechanism of these is the same in every respect. The slubbing-frame, which receives the cans from the drawing-frame, has no racks or creels, which are required in the other two for the purpose of holding the feeding bobbins. The slub, or roving, as the cotton is called after it has been twisted into a soft cord, being reduced in size or grist at each successive frame, smaller bobbins are sufficient to hold it. This permits the spindles to be set closer, and as the frames are lighter and more easily driven, they contain a greater number of them. The following table gives twists per inch on the roving, etc., and an approximate estimate of the produce of the different frames. "Lift" means extreme traverseof the rail.

Frames.	Lift.	Diam. of Bobbin.	Revs. of Spindle per min.	Size of Roving.	Twists per inch.	Produce in 60 hours.
	in.	in.		hk.		lbs.
Slubbing	12	6	700	·5	2·71	100
"	10	5	800	1	3·7	64
"	10	5	900	1·5	4·6	46
Intermediate	8½	4	1000	2	5·47	33
"	8½	4	1100	2·5	6·29	25
"	8½	4	1200	3	7·06	20
"	7	3½	1200	4	8·3	13
"	7	3	1400	6	9·88	8
Finishing	7	3	1400	8	11·29	5
"	6	2½	1600	10	12·35	4½
"	6	2½	1600	12	12	3½
"	6	2½	1600	14	12·5	2¾
"	5	2¼	1600	16	13	2¼
"	5	2¼	1700	18	13·5	1¾
"	5	2¼	1700	20	14	1¼

The amount of twist given to the roving should not be more than sufficient to enable it to be wound upon and taken off the bobbin. A soft rove is best adapted for being drawn. At Fig. 1 an elevation of the fly-frame is shown. Fig. 2 shows it in section. The can A supplies the sliver, which after being taken over a guiding-rod, is passed between a series of drawing-rollers, B, fixed upon the frame C. Thence it passes down to the flyer D, which winds it upon the bobbin F. The machinery which accomplishes the various movements is very ingenious and complicated. No machine connected with this branch of manufacture has undergone greater improvements, or has been brought to greater perfection.

The rollers are similar in principle and arrangement with those of the drawing-frame. They are usually arranged in three pairs, the lower ones being fluted, and the upper ones, with the exception of the first, which is fluted also to take a better hold of the cotton, being covered with flannel and leather. The circumferences are held tightly together by means of weights hung upon the top ones. The draught is principally between the middle and front rollers. The cleaners rest upon the top rollers as in the drawing-frame. Leaving the front roller, the roving enters the tube of the flyer (Fig. 3) at A, passes out by an eye near the top of it, and down the hollow leg to B, after which it is turned once or twice round the "finger" or presser, and deposited by it upon the bobbin at C. The centrifugal presser is an exceedingly simple, and yet a most admirable invention for consolidating the rovings upon the bobbin, and thus enabling it to contain a much larger quantity than otherwise it could. It is hinged at D and D^1 upon the leg of the flyer, so that it swings with perfect freedom. Between those two points lies its greatest weight. As the spindle revolves, it acquires a considerable centrifugal force, which causes the finger D^2 to press with a corresponding force upon the successive layers which it puts upon the bobbin. The object of twining the roving round the finger, is to keep it as tight as possible when being wound up for the same purpose. The seldomer the bobbins require to be changed or "doffed" the less work is entailed upon the attendants. The flyer itself is a very nice piece of workmanship, great care being necessary to have it properly balanced, so that there may not be an undue tear and wear of the bearings of the spindles. These latter have their ends slightly tapered so as to fit into the tube of the flyer at E, until a slot in the end receives a pin, which crosses the tube for the purpose of making a thorough connection between the two. It is necessary that the flyer should be movable, so that when the bobbins are full they may be taken off and be replaced by empty ones. The bobbin has no connection with the spindle, merely running loose upon it, whilst it rests upon the top of a small wheel G (Fig. 2) which has a pin fitting into a slot in the end of it. This, as it revolves, carries the bobbin along with it. These bobbin-wheels G are driven by two horizontal shafts, attached to the lifting-rail E, E, and running along the front of the machine. The spindles are driven by similar shafts gearing into the small wheels H, H at the bottom of the frame. In consequence of the bearing or collar in the lifting rail being so far from the end of the spindle, the weight of the flyer has a tendency to throw it off the truth and waste it. To remedy this evil a long collar has been very largely introduced. This is screwed firmly to the rail, and encircles the spindle till it reaches nearly to the top of the bobbin. To prevent friction, it is hollowed out, so that it is only at its extremity that it bears upon the spindle. This necessitates the use of a larger spool which lessens the quantity of roving which can be run upon it. Otherwise it makes a very advantageous arrangement.

The speed of the spindle is fixed and uniform, and the quantity of roving delivered by the rollers is uniform when once that quantity has been adjusted to suit the amount of twist to be given it. This being so, the flyers making a fixed number of revolutions in any given time, and the front roller delivering a fixed number of units of roving, it is obvious that the bobbin must have a varying motion corresponding to its ever-increasing bulk as each new layer of roving is wound upon it. The "differential motion" accomplishes this by a curious and most ingenious combination of wheels. I shall endeavour to explain this by a reference to Fig. 4. This shows the principal machinery of the fly-frame. It is placed at the end of the frame, and is neatly inclosed with iron to prevent accidents, and to exclude dust and waste. The driving-pulley and fly-wheel are upon the main shaft A A, which passes right through the wheels C^2 and D, which are loose upon it, and have a separate motion. The wheel C is fixed upon it, and drives C^2 by means of the internal wheels C^1 and C^3. C^2 is in one piece with the wheel E, which, by its connecting wheel E^1, drives the bobbin-

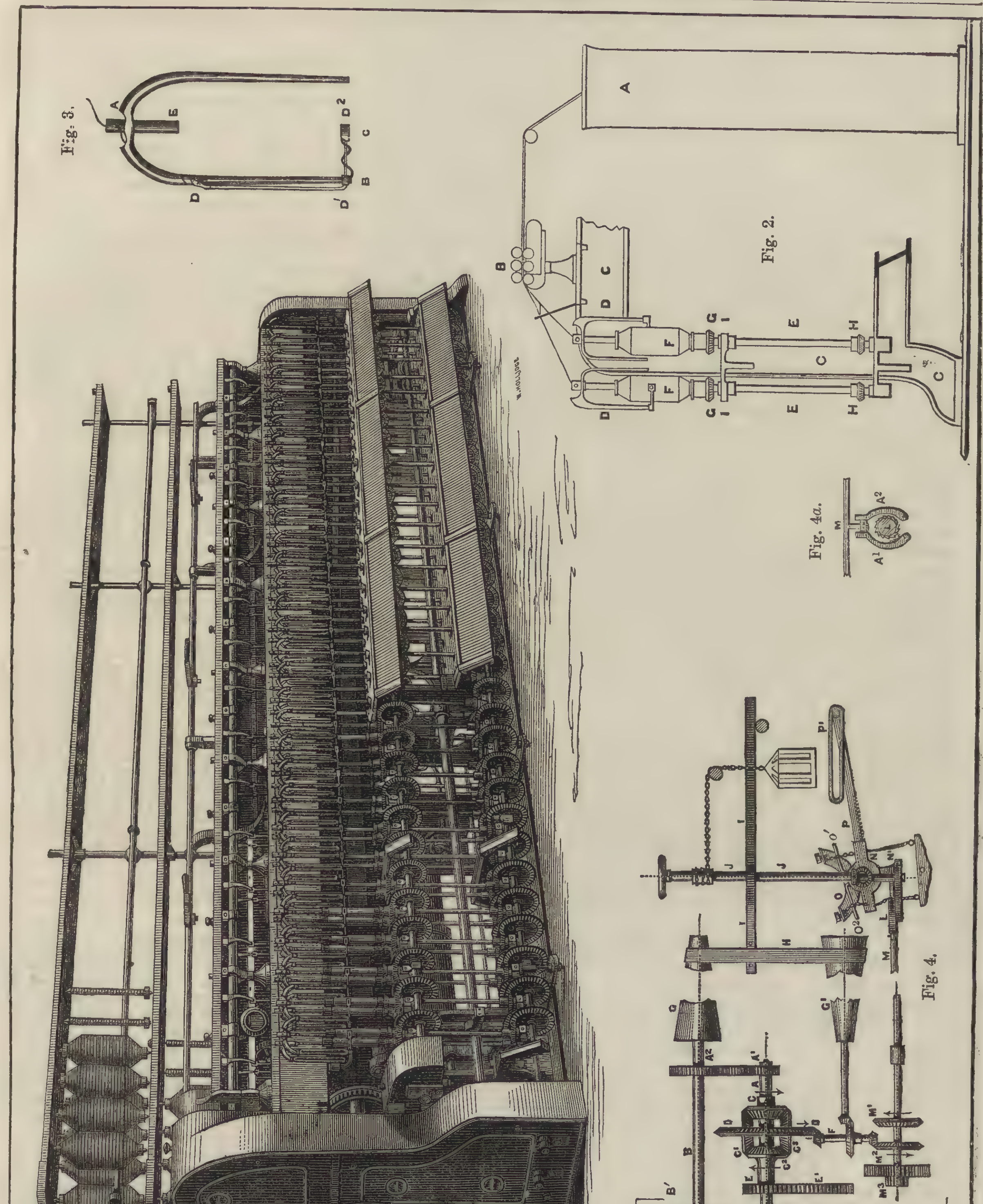


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 4a.

shafts running along the lifting rail. If the large wheel D were to remain stationary, the bobbin-wheel E would make exactly the same number of revolutions as the main shaft, C and C^2 having the same number of teeth. But if it revolve in the same direction as C, it will reduce the speed of E by so much. This will be better understood by supposing C to be thrown out of gear, and C^1 and C^3 to be fixed so that they cannot revolve upon their axis. If then the wheel D is made to revolve once in the direction of the arrow, C^2 being held by the internal wheels must also make one revolution in the same direction. But if we suppose the wheel C brought into gear again with C^1 and C^3, and these to be set free to turn upon their axis whilst C remains stationary, one revolution of D will cause the internal wheels to make one revolution, which, being communicated to C^2, will cause it to make one revolution more than before. Thus *one* revolution of D in either direction makes a difference of *two* revolutions in the speed of C and E. The large wheel D therefore controls the speed imparted to the bobbins through the wheels E and E^1, etc.

The roving may be wound upon the bobbin in two ways: either by the bobbin "leading" or outstripping the flyer, or by the flyer outstripping the bobbin. In the first case the bobbin is at its highest speed when it commences to lap up the roving, and its speed must be diminished in exact ratio to the increase which each new layer of roving makes in the circumference of the bobbin. In the other case when the flyer "leads," the speed of the bobbin is at its minimum when it begins to wind up, and consequently must increase so as to counteract the constantly increasing quantity of roving which each revolution of the flyer puts upon its circumference. In this case let us suppose that the bobbin leads. Its speed must therefore be diminished with each new layer of roving by the controlling wheel D being driven in the direction of the arrow with an accelerated motion. This varying motion is communicated by means of a pair of cones. The main shaft A by connecting wheels drives the cone G, which by a strap drives the opposite cone G^1, which in turn drives the controlling wheel by the small upright shaft F. At the commencement of the bobbin the strap H is moved back from the larger to the smaller end of the driving cone. This is done by the operative turning the wheel upon the top of the shaft J, which shaft moves the strap-guide by means of a pinion working into a toothed rack I I. At the same time a chain to which a weight is suspended is wound upon the barrel S. The tendency of this weight to cause the shaft J to revolve is held in check by an escape movement and ratchet wheel L, which shall afterwards be described. At the commencement of each new layer of roving the ratchet wheel is allowed to revolve to the extent of one tooth, and a proportionate movement is given to the strap, which thus gradually travels to the larger end of the driving cone, and so the necessary increase of speed for D is acquired. Each shift of the strap is calculated to compensate with the greatest exactness the increase in the bobbin.

The rail which carries the bobbins, bobbin-wheels, driving-shafts, etc., travels in slides, and is balanced by heavy weights. As the bobbin increases in size, this rail, which lifts and lowers the bobbins upon the spindles, so that the pressure of the flyer lays the roving regularly upon it, requires to move more slowly in exact proportion to the diminishing difference between the speed of the flyer and the bobbin. This also is accomplished by means of the cones. The shaft F drives through the wheels M^1 and M^2, and the wheel M^3 a shaft which stretches along the frame, and which works by small wheels upon a number of vertical racks which are fixed to the rail. According as the shaft F is in gear with the wheel M^1 or M^2, the rail rises or falls. This is controlled by the rod M attached at N^1 to N oscillating upon the same stud as O. O is worked by a lever rising and falling with the rail. N has two springs attached to its extremities, which act upon it with equal force, until the lever brings down or raises the opposite ends of O, when it is relieved of one of the springs by the chain lifting it. This motion of O continues until the screw comes down upon a catch, O^1 or O^2, which keeps N from yielding to the spring. When it has come down and relieved the catch, N at once oscillates to the side which is pulled by the spring, and in doing so jerks the rod to the right or to the left as the case may be, and at once reverses the motion given to the rail. This same movement of the rod acts upon the escape motion, by which the ratch-wheel L revolves, and allows the shaft J to move the belt-guide. The escape motion is shown in plan at Fig. 4*a*. The two jaws A^1 and A^2 work upon studs at the further point from the rod M, and their two opposite ends are held together against a projection upon M by a spiral spring. Inside A^1 and A^2 hand catches are placed, so that when one is thrown out by the jerking of the rod the other catches after the ratchet has made a slight movement.

Not only does the speed of the bobbin and of the travelling rail vary, but the length of travel of the rail is always diminished with each new layer of rove. The purpose of this is to bevel, or give a slope to the end of the bobbin, so that there is no danger of one ply of roving falling over the preceding one. This shortening of the distance traversed by the rail is effected by the shortening of the lever P, which is drawn through O. Upon its under side there is a ratch which is worked by the stud which supports N and O, and which having a small wheel working into it, whilst the other end is geared to the upright shaft J, so that every motion it makes is communicated to the lever, and shortens it by driving it through O, and bringing it along the slide P^1, which is attached to the rail. Thus we have the speed of the bobbin varied by means of the differential motion; the rate at which the bobbin rail travels, by the cones; and the shortening of the "lift" by the shortening of the lever, as well as the alternate rising and falling of the rail.

The rollers are driven from the main shaft by the wheels A^1, A^2, and B^1, and the spindles are driven by the wheels E and E^1. The speed of the spindle is never altered. But the speed of the rollers and bobbins are adjusted occasionally to suit the twist which is to be put upon the roving. Thus, if a little more twist is required, the rollers must give out the cotton more slowly, and the bobbins wind it up more slowly, so that the roving passing from the roller to the flyer must necessarily undergo the twisting of the spindle for a longer period. The change-wheel for this purpose is A^1, which drives the rollers, and regulation motion for bobbins.

The shafts and wheels for driving the spindles, as well as those for driving the bobbin in the lifting rail, are inclosed either with boards or sheet iron. To alter the size of the roving, the relative speed of front and back roller is increased or diminished by means of the pinion driving the back roller. Between the rollers and the flyers there are separating plates, the purpose of which is to keep the rovings from coming into contact with each other, and thus breaking and causing waste. As has already been said, there is no material difference between the slubbing, intermediate, or finishing fly-frame, and when the cotton has passed the last of these, it is then sufficiently reduced to be taken to the throstle-frame or mule.

PHOTOGRAPHY.—XIV.

By J. C. Leake.

PHOTOGRAPHIC CHEMICALS.

As we explained in our first article on this subject, the art of photography is based upon certain chemical reactions of the most delicate character; it may therefore be concluded that if these are induced, the success of the various photographic processes may be considered as certainties. It is not often, however, that anything like absolute certainty is ensured in photographic operations; but this must not be attributed to an uncertain action of the chemicals employed, but rather to the difficulty of ensuring exactly the same conditions under differing circumstances. It may be stated as a fact, that under certain conditions the same chemical result may be always obtained, and that where this is not the case it is due to the dissimilar conditions, although the difference may be so delicate as not to be readily ascertainable. As it frequently happens that a rise or fall of temperature will cause a complete failure in photographic operations, although the change may be scarcely perceptible to the operator, it becomes most important that the greatest care should be exercised in all parts of every process, and especially in the procuring of chemicals of the utmost purity.

One of the most frequent sources of failure in the photographic processes is the use of impure water. As we have before remarked, all solutions of nitrate of silver should be mixed with

water which has been distilled. Even distilled water, however, is not always to be trusted, especially when purchased in cities, as it not unfrequently happens that the droppings from steam-pipes are supplied instead of the genuine article. These are frequently tainted with oily matter from the engine; and as but little care is taken in properly cleansing the vessels in which the water is collected, it is often as bad or worse than ordinary rain-water. The best method of obtaining perfectly clean and pure water for the nitrate-of-silver bath is to distil it in a glass retort as required. Pure distilled water should leave no residue on evaporation, and should remain perfectly clear on the addition of nitrate of silver, even after exposure to strong sunlight. It should also be perfectly neutral to test-paper. Spring-water is usually tolerably free from organic matter, and may be used for the nitrate bath if distilled water cannot be procured. A small proportion of the silver is of course precipitated by the chlorides and carbonates present, but beyond a slight weakening, the solution should not be deleteriously affected. It is, however, not to be supposed that all well-water is commonly pure and free from organic matter, as we have met with some which struck a decided brown tinge after a few hours' contact with the nitrate. Rain-water is most certainly not to be depended upon, save in exceptional cases, as it is frequently contaminated with ammonia and other matters, especially in the vicinity of large towns.

Although not so important as in the case of the nitrate bath, the water employed for developing solutions should be as pure as possible. It should be remembered that (in the wet collodion process at any rate) a certain amount of silver is retained in and upon the film, and that the application of a developing solution containing a chloride or other impurity will cause a precipitation of the silver which may seriously interfere with the development. In one case within the writer's experience, the turbidity caused by impure water was so great, that only an exceedingly weak image could be obtained, while the defect was completely overcome upon the employment of distilled water. Doubtless, many failures are caused by the use of impure water in the dry processes. Perhaps in the collodio-albumen process the effect is least felt; but it will be better to employ distilled water when possible in all parts of the process until the development and intensification are completed.

Although in most cases the photographer will probably purchase his collodion ready prepared, occasion may arise for the preparation of this material at home. We therefore append one of the most approved formulæ for that purpose.

As is well known, collodion is a solution in ether and alcohol of a substance known as gun-cotton, or more properly *pyroxyline.* To the solution thus made, in order to fit it for photographic purposes, is added a certain proportion of an iodide and bromide, which combining with the nitrate of silver in the bath forms a sensitive film upon which the image is impressed in the camera. The first solution to be made is that of the plain collodion, which is prepared as follows:—Take of the finest cotton wool eight ounces, and boil it for some hours in a solution of carbonate of potassa, four ounces; water, three gallons. This process is employed to cleanse the fibre of the wool from grease and other impurities. After this the cotton must be washed to remove all trace of the alkali, and thoroughly dried. In order to convert this cotton into pyroxyline, sulphuric acid and nitric acid must be mixed in the following proportions:—Sulphuric acid, of the specific gravity 1·843, five fluid ounces. Nitric acid, specific gravity 1·437, four fluid ounces. The acids should be mixed in a porcelain vessel, and placed in a second vessel containing water, the temperature of which can be maintained at 145°. At first the temperature of the mixed acids will be higher than this, but as soon as this temperature is reached 200 grains of the dried cotton wool should be immersed in small portions by means of a glass rod. The dish must now be covered, and the cotton allowed to soak for eight minutes. After this it must be taken out of the acids and plunged into clean cold water—of course using the glass rods for this purpose. The cotton must now be most thoroughly washed, in order to remove every trace of acid. This is most important, and the washing water should be tested with litmus paper, in order to ensure the perfect removal of the acids. The cotton may be dried in the sun, or in a current of air, and it should be remembered that it is now explosive, and consequently must be carefully guarded against fire, or any higher temperature than about 120°.

In order to make this pyroxyline into plain collodion, it must be dissolved in the following mixture:—Alcohol, specific gravity ·806, 1½ pints; ether, specific gravity ·720, 2½ pints; to this add pyroxyline in small tufts, 1,000 grains. The cotton should be well moistened in the alcohol before the ether is added. The cotton will quickly dissolve, when the mixture should be set aside in a cool dark place, and decanted off for use as required.

The iodising solution is made as follows:—Dissolve in ten ounces of pure alcohol, two drachms of iodide of cadmium, eighty grains of bromide of cadmium, and forty grains of iodide of ammonium. In order to iodise the collodion for use, one ounce of this mixture must be added to each six ounces of plain collodion. It will sometimes happen that there will be a slight tendency to fogging with this collodion; if so, add a few drops—say one to each ounce—of alcoholic tincture of iodine. It need perhaps scarcely be observed that, in working with such highly inflammable materials, care must be taken to avoid accidents by fire.

Next to collodion, the most important substance used by the photographer is the nitrate of silver. This can easily be made at home, although it is questionable if it is any cheaper to make than to buy it. In order to prepare this salt, dissolve two ounces of pure metallic silver in two ounces of pure nitric acid by the aid of heat; add silver until the acids refuse to dissolve more. Evaporate the acids so as to leave the crystals dry; dissolve the mass in a small quantity of boiling distilled water, and set aside for a day to crystallise; collect the crystals, dry, and fuse. Sometimes the fused mass is again dissolved in water and re-crystallised, but this is not necessary, when the silver is to be employed for printing. For the ordinary purposes of photography, one solution of the crystals will be sufficient; but for use in the nitrate bath used for collodion plates, it is advisable to adopt a second washing. In most cases, unless special care has been taken in the preparation of the salt, a solution of nitrate of silver will be found to have an acid reaction, which in the case of the nitrate bath must be neutralised by the addition of a small quantity of carbonate of soda.

The chloride of gold employed for toning photographic prints may also be readily made at home; and as this salt as supplied in commerce is frequently impure, and does not contain the proper quantity of metallic gold, it is advisable to prepare it so as to ensure proper strength and quality. The following is a simple and effective method of preparation:—Place in a suitable vessel a half-sovereign, and pour upon it half a drachm of nitric acid, mixed with two and a half drachms of hydrochloric acid, and three drachms of water. Apply a gentle heat, but do not boil the mixture. After a few hours add a second quantity of the mixture, and if this does not effect the solution of the metal, a third may be applied. Neutralise the product thus obtained by adding carbonate of soda until all effervescence ceases. A green precipitate will form which will be carbonate of copper, and which must be allowed to separate thoroughly, a process which will occupy several hours. The solution thus obtained will be slightly alkaline, and as this is likely to promote a reduction of the gold to a metallic form, a drop or two of hydrochloric acid should be added after the removal of the precipitate. A convenient plan of keeping the chloride is to dissolve it in a known quantity of water, so as to make it, say five, grains to the ounce of solution. It can then be measured without loss. A half-sovereign contains about fifty-six grains of pure gold, which will make eighty-six grains of the chloride. Chloride of gold should be mixed in distilled water, as any trace of iron will precipitate gold in the metallic form.

Some difficulties at times occur through the varying strength of the acetic acid commonly supplied. That usually employed in photography is what is termed glacial, and should become solid at about 40°. It should contain only one atom of water. Many persons use a cheaper acid, known as "Beaufoy's." This is the "acetic acid fortiss." of the London Pharmacopœia, and contains about 30 per cent. of acid. From this it follows that rather more than three times the quantity of this acid must be employed where it is substituted for the glacial.

In concluding this subject, we would caution the photographer against the employment of impure and, as they are termed, cheap chemicals. It is but seldom that materials sufficiently pure can be obtained at the ordinary druggists, and in all cases it should be stated that they are required for photography. Under the recent Act for regulating the sale of poisons, no person can be supplied unless accompanied by a witness who knows the purchaser, and the purpose for which the poisons are required.

THE LATHE.—XVIII.

By Henry Northcott.

LATHES FOR SPECIAL PURPOSES (*continued*).

The latest novelty in the way of special lathes is an invention recently patented in this country by Giovanni Sconcia, but being a communication from Frederick Baldwin, of the United States. The invention is thus described in the "complete specification" filed at the Great Seal Patent Office :—

"The object of this invention is to manufacture chair legs, round tool handles, and other similar plain and fancy articles from wood, metal, or other hard material by means of a lathe of special construction, the feeding and shaping portion of the mechanism being made self-acting.

"The invention consists of a machine of a lathe-like form provided with a hollow mandril, through which the blank to be reduced or shaped is caused to pass by a feeding mechanism which acts automatically as the cutting or reducing progresses.

"The feeding mechanism consists of a pair of rollers, one of which is plain and the other toothed or serrated to give sufficient grip or hold of the blank under operation. The rollers are adjustable by springs, so that blanks of any size, within the diameter of the hollow mandril can be placed between them. The blank as it leaves the feed rollers is acted upon by rotating cutters which reduce the wood or metal to a circular form to prepare it for the shaping cutters. The blank then enters the hollow mandril and passes through it, when the shaping cutters are caused to act and produce hollows and projections upon it according to the shape of the pattern plate, which is upon a wheel on the side of the machine. The wheel carrying the pattern plate is fitted in a slot in the frame, so that it can be removed and others placed in its stead, according to the length of the article to be produced. The cutters are preferably of V-shape, and revolve at a high speed; they are caused to act upon the blank to give it the proper form and shape by means of a pin which works against the pattern plate. The cutters are adjustable, and follow the undulations of the pattern by means of springs; they are connected by hook-bolts to bell-cranks pivoted at the junction of the angles to ensure their proper working. Clutches are arranged to throw the working parts into and out of gear as required.

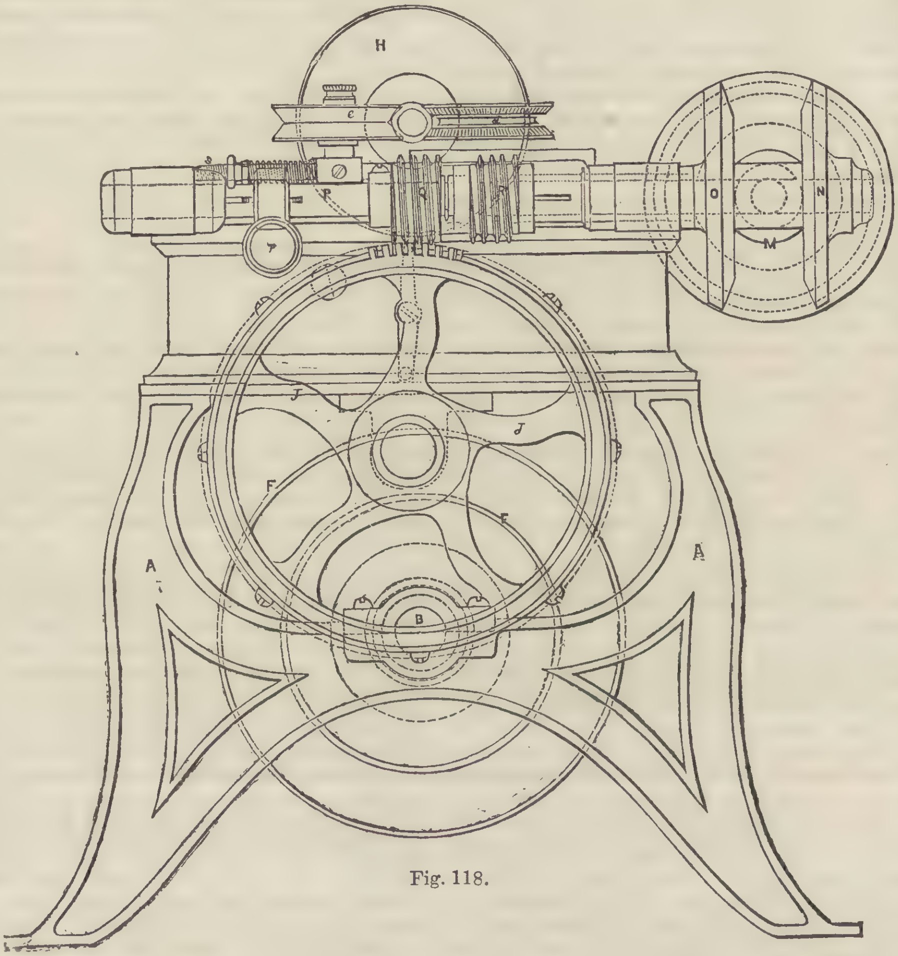


Fig. 118.

"The article as it leaves the shaping cutters is received by an automatic holder, which is also a polisher or finisher, so that the article before it finally leaves the machine is in a finished state. This mechanism consists of a set of revolving polishing wheels, which have an independent forward travel to carry the work along.

"The invention will be well understood by the accompanying drawings, in which the lathe is shown in its complete form in the several figures.

"Fig. 116 is a sectional elevation through the line 1, 2, of Fig. 117, which is itself a plan or view looking on the top; Fig. 118 is a view looking on the end at which the wood to be reduced enters; while Figs. 119, 120, 121, 122, and 123 are some of the details. The lathe is composed of standards or a frame A, supporting at its lower part a shaft B, on which the fast and loose pulleys C, D are mounted for communicating the necessary rotatory movement to the other parts by means of the pulleys E, F. The straps from these pulleys pass up between the frame A and over the discs G, H, for the purpose of rotating them. The pulley E is of larger diameter than the others on the same shaft by reason of the greater speed necessary to be given to the disc G, which carries the shaping cutters or knives. The discs G, H, are supported upon a tube or mandril *a* fixed upon or in a cross brace or bracket I, and at or about the centre of the frame A. A portion of the exterior of the tube is threaded, and has a conical head to hold the disc G in place, the opposite end of the tube being plain and of less diameter on its exterior for the reception of a conical socket *c* which holds the disc H in place. Both these discs are thus free to revolve against or upon the cones without imparting a corresponding movement to them. By this means, with the aid of the bracket I, the tube or mandril is held firmly in position to act as a guide to the wood as it is passing through. The disc H is termed the reducing disc, because it carries the knives or gouge chisels *f*, *f*, for reducing the wood, as it leaves the feeding-rollers *d*, *e*, to the proper diameter for passing through the tube *a*, supposing the wood to be of a square or other similar shape and require reducing. These cutters *f*, *f* are arranged on the outer face of the disc H, and are capable of being adjusted by loosening the screws *g*, *g*, and shifting them as desired under the plates *h*, *h*, one of which only is shown in Fig. 119. The other or shaping cutters *i*, *i*, which are carried by

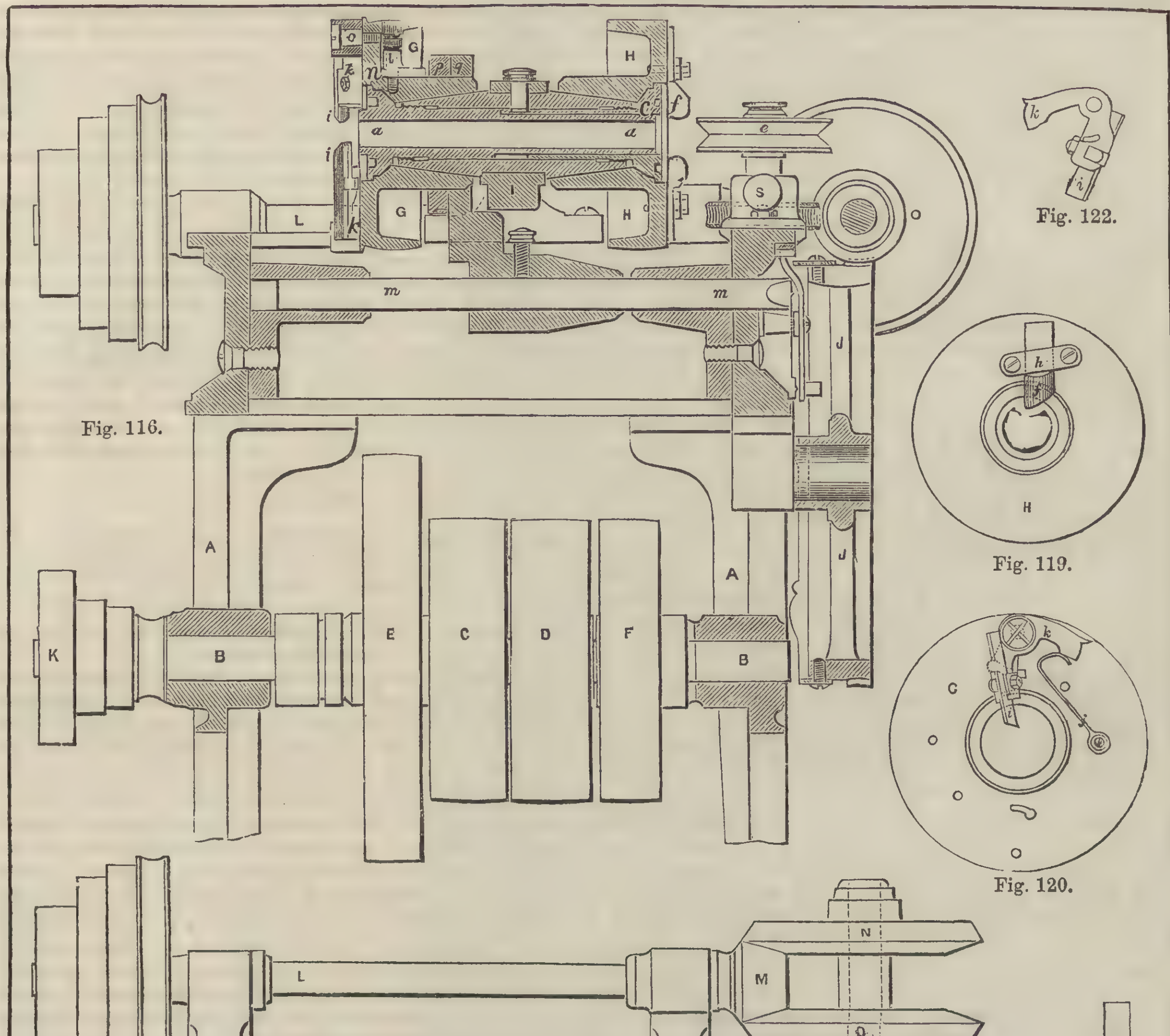


Fig. 116.

Fig. 117.

Fig. 119.

Fig. 120.

Fig. 121.

Fig. 122.

Fig. 123.

the disc G, are capable of automatic adjustment by the action of their springs j, j, as will be seen on reference to Fig. 120, which is a detached view. In this case the springs act direct upon tail-pieces of the holders k, k, which are in connection through crank-plates l, l, with a rod m made to bear against the edge of a wheel J or a pattern plate fixed on it. It will be found of greater convenience to have separate pattern plates for practical working, and these may be formed with slot and screw holes, so that they can be adjusted into position and screwed home tight in a short space of time, and thus prevent delays in changing the patterns. The crank plates are formed with noses n, n, and the side motion of them ensures the cutter holders moving on their pins o, o, to overcome the pressure of the springs j, j. These cutters are V-shaped, and are held in the holders by screws, clips, or other appliances. The crank plates are held in position under the rim of the disc G by pins which are passed through from the outside, and their movement is established by rings p, p, on their outer ends, the rings being actuated by other rings or forks q, q, connected to the rod m. The first motion shaft B has on a projecting end a cone pulley K for giving rotation by a strap to a shaft L arranged at the back of the frame; this shaft L has a bevelled pinion M on it gearing into two bevelled wheels N, O, to give motion to the feed rollers d, e, and the wheel J carrying the pattern plate. One of these bevel wheels is fast upon a spindle P, and this spindle carries a worm Q in gear with a worm on the pattern wheel J, so as to work it round, and thus shift the parts of the pattern in proper order; the other bevel wheel is on a sleeve which carries another worm R in gear with a worm wheel on the same axle as one of the feed rollers, so that the feed roller d partakes of a corresponding motion therewith, and thus feeds the wood into the lathe to be acted upon by the cutters. The feed roller d has a serrated edge to ensure obtaining sufficient grip on the wood to pass it into the lathe; the other roller e, which is plain, is free to rotate by the action of the wood against it: it is, however, adjustable in its support, so that it can be fixed nearer to or farther from the feed roller by means of a screw s, a little allowance for play being given by means of a spring. The worm, sleeve, and its bevel wheel are always running in the same direction for the purpose of the feed, but the other worm, which is on the shaft, can be slid along and become disconnected from it and put into contact with the first-named worm; by this means the pattern wheel can be driven in either direction for the purposes of repeating the pattern, or a portion of it, if desired. This is done by a projecting button head r and a rod t (Fig. 121), being moved to one side, the rod t having a connection through a pin with the worm collar. The hollow mandril can be reduced in diameter by inserting short tubes into it: thus, if the mandril is, say, one foot in diameter, to allow wood of corresponding diameter to pass through it, it can by the insertion of tubes be so reduced as to pass only 6-inch diameter wood through, or any given size between the twelve inches and the six inches, when by adjusting the knives on the discs they would operate upon the smaller diameter wood in the same manner as they would have done upon the largest diameter. This is a great feature in this invention, as by it articles can be turned and shaped of almost any extreme difference in diameters in one machine.

"There is scarcely any limit to the number or variety of articles which can be produced by this lathe. Among them may be mentioned wheel spokes and naves, chair legs, table legs and rails, banister columns, penholders, billiard cues, crochet needles, broom handles, furniture knobs and rails, piano action rods and walking sticks, knife and tool handles, vent pegs and railway trenails, curtain rods and bedstead poles; in fact, as before stated, there is no end to the variety and number of plain or fancy articles of circular form that can be made by it, whether they be plain parallel, plain tapered, ornamental parallel, or ornamental tapered in the whole or only a part of their length. All that has to be done is to set the machine in motion, and enter the stuff between the feed rollers, keeping up piece after piece as the work is completed for any period of time. The degree of finish to the articles will, of course, depend much upon the sharpness of the cutters and the speed at which they and the discs are driven, and with most woods they will be found fit for use without any after treatment, but if extra smooth articles are required, a pair of polishing rollers can be arranged to receive the articles after they leave the cutters. These rollers, in addition to rotating, can be made to slide to and fro endwise to give the required degree of polish; after which the articles can be cut off by a saw or a cutting tool so as to sever them from each other, or if the extra polishing is not required the cutting off can be effected by the shaping cutters of the disc G.

"In the case of a small lathe, corresponding in size to that shown in the drawings, a length of wood can be cut as fine as ordinary wire or twine without damaging the fibre, as no strain or twist is put upon the wood while under operation.

"I have in the foregoing description only referred to turning or reducing wood, but by varying the speed and the shape of the cutters, metals and other hard materials can be operated upon."

This lathe is a very different sort of machine to that used for ordinary turning. It may be considered a continuous turning machine, as it works continuously upon the wood presented to it, instead of each piece requiring to be separately chucked and turned. The tools also in the lathe rotate instead of the work, and indeed there is very little about the machine that resembles the ordinary lathe. To find any resemblance we must go to the work it produces, of which some very cleverly turned samples have been exhibited, some of them being so thin that they could be bent and twisted into any intricate shape, and even tied into knots like a piece of string.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XVIII.—SCHOOL MUSEUMS.

THE AIMS OF A SCHOOL MUSEUM IN RELATION TO SCIENCE-TEACHING (*continued*).

HAVING mastered the terminology of mineralogy, botany, and zoology, and, through demonstrations, become conversant with the methods and implements of research, the student is in a position to appreciate the value of the principles of classification and the laws of natural-history nomenclature, and to comprehend a systematic description of the typical representatives of the great divisions of the three kingdoms of Nature. Next in order might come the natural history of the solar system, leading up to that of our earth—the meteorological and other influences that affected its physical aspects in its past and present condition, the distribution of mineral matter, and of vegetable, animal, and human life over its surface. Such a course would only impart but a general knowledge of the earth on which we live, of what was in it, on it, and about it. In imparting it, every assertion should, as far as possible, be proved by demonstration, for in science every child ought to be taught "that it is his duty to doubt, and not, till he is compelled by the absolute authority of Nature, to believe that which is written in books."

Can it honestly be said that such an elementary science course embraces more information than every person claiming the title of "educated" should possess on leaving school? The private gentleman would find time hang less heavy on his hands if he were trained what to observe and how to observe in all matters connected with his sports, pastimes, and travels. The artist, who may be regarded as twin brother to the naturalist in the family of observers, would be trained to observe more accurately, and to avoid committing scientific errors or anomalies to canvas. The minister of religion, whose office ought to rank highest among the professions, can scarcely serve his Master completely till he is conversant with "the Word of God as revealed in facts" (as Bacon has it), nor till then can he be "in a position to understand the difficulties in the way of accepting those theories which are forced upon the mind of every thoughtful and intelligent man who has taken the trouble to instruct himself in the elements of natural knowledge." The judge would often be better armed for the exercise of his awful responsibilities were he trained to weigh the value of scientific evidence by the methods of the naturalist, though from our experience of human nature we can hardly expect that the advocate (whether a legal or technical one) would employ any scientific training he might acquire as an honest weapon of attack or of defence.

The classes thus far enumerated have been, until a very recent period, sent forth into the world without a rag of information as to the nature of the planet on which they live, or of the body that houses their soul, and with small chance of their acquiring such

kind of information during their professional training at our universities. Unless some inborn instinct forces them to seek such knowledge for themselves, how much of modern literature must remain but as a dead language, how much of modern intellectual society be but as a charmed circle, wrapped in impenetrable mystery! The medical, army, or navy man, the architect, the engineer, the mine-master, the manufacturer, the agriculturist, and the commercialist is either taught at a special school, or he "picks up," in the course of business, such portions as meet his needs of the grammar of science, of which he has not been taught the alphabet. Is it to be wondered at that so much professional and commercial practice is still governed by "the rule of thumb?" Well might Professor Huxley have entered the following protest:—"What is it but the preposterous condition of ordinary school education which prevents a young man of seventeen, destined for the practice of medicine, being fully prepared for the study of Nature, and coming to the medical school equipped with that preliminary knowledge of the principles of physics, chemistry, and of biology upon which he has now to waste one of the precious years, every moment of which ought to be given to those studies which bear directly upon the knowledge of his profession." He might have made a similar protest against the schooling of those students who are sent to the School of Mines, unfledged as to the rudimentary features of science, for I well remember, during his second year at Jermyn Street, some of the youths had never heard of insect metamorphosis, so he had good cause for regret that valuable time should be wasted in his having to dwell on the veriest rudiments of biology.

At what period in life should science-teaching commence? Professor Henslow has proved that an expert teacher may begin with advantage on the youngest even of a village school class, and he gave as his experience that children show great avidity to learn even such subjects as practical botany. At Rugby, even when dealing with boys of fourteen, their experience was not of so satisfactory a character. "For the first half-year of 1865 natural science was taught to every boy in the middle and lower school, the sixth form and upper school being allowed to choose between German and natural science. After six months' experience, however, it was decided to drop the subject in the lower school, the boys appearing hardly equal to the work." But much depends upon what is attempted and the manner of teaching, for a master who may be very successful in dealing with youths, might fail utterly with mere boys, and it requires special tact for a teacher to bring his ideas and modes of expression down to the level of a child's comprehension and create an interest for what many would regard as dry subjects, which, nevertheless, have been made subject-material for amusement in the Kinder Garten. If science is to be taught in our schools, there is no reason why a beginning should not be made in the first spelling-books, and statements of facts be made to replace the silly sentences to be found in existing primers, without making them of the Gradgrind class. It is now the almost universal custom to divide our public schools into three divisions, the *lower*, *middle*, and *upper*, and to adopt the *bifurcating system* after the middle school has been passed, that is to say, to give a youth the opportunity of selecting his future course of study, either in the *classical and mathematical*, or in the *modern* division, as his future may be destined for a university education, or medical, military, naval, mechanical, or commercial training, and in some schools this system is still further elaborated; such a system is founded on a common-sense view of the difficulties presented by the requirements of modern education, and is well adapted to meet the aims of science-teaching, if supplemented by what might be called the "practical science" division. Thus, supposing a science lecturer and an assistant under the title of examiner in science, were appointed both in the lower and middle schools, such an elementary course as I have previously indicated could be thoroughly mastered by any boy who had passed both divisions. The superintending masters should be appointed for their qualifications as naturalists, while the masters in the upper school should be appointed for their qualifications in chemistry, physics, and applied science; as the aim of the upper school course should be to impart general instruction of an advanced character in chemistry, physics, etc., and special instruction in the "practical science" division, according to the requirements the professional or commercial future of a boy might demand, for which purpose the boys should be sorted into "sets," such as medical, mechanical, agricultural, manufacturing, commercial, etc., and the nature of the observing, analytical, and operative processes selected by the masters, should be suited to each set. All belonging to the upper school should undergo an elementary course of observatory and meteorological practice, and also exercise as "field naturalists," with a view of adding to the "local collections" of the school museum, in addition to practice as collectors. Such a practical course would provide ample exercise in the processes of *deduction* and *verification*. The members of the upper school should be encouraged by the co-operation of all the masters to establish societies and publish annual reports, as these afford good practice in composition, in speaking and experimenting in public, which tend to give youths a calm and collected bearing in society.

In the lower school a lecture, illustrated experimentally, should be given on alternate afternoons, on the principles and terminology of natural history, in a lecture theatre large enough to hold the entire division. All specimens, diagrams, etc., should be left, and on the following morning the examiner should meet the same class, and receive from each boy the best-written report he could give, illustrated with diagrams of the previous day's lecture, especially dwelling on terms and their derivations. He should then conduct a *vivâ voce* examination on the previous day's work, and ascertain that the subject matter was fairly mastered. After the class was dismissed both lecturer and examiner would be free to replace all apparatus, diagrams, etc., in the museum, and prepare for the next day's lecture. For those boys who were in doubt on any point discussed, a question-box should be provided, into which they could drop written queries. On a third day in the week the lecturer should give a summary of the two previous lectures, and repeat or enlarge upon those points on which questions had been raised, thus making sure that the week's work had been thoroughly comprehended. The reports of the week's lectures should be returned to each boy, duly marked according to their value. On the other alternate afternoons and mornings in the week the lecturer and examiner of the middle school should, in a similar manner, treat the subject of descriptive natural history, so that the week's work in the lower and middle schools would stand thus:—

Days of Week	M.	T.	W.	Th.	F.	S.	M.
Afternoon Lecture	M_1	L_1	M_2	L_2	M_3	Holiday ‡	M_1
Morning Examination *	—	M_1	L_1	M_2	L_2		M_3
Morning Summary †	—	—	—	—	L*		M*

L indicates Lower, M Middle School.

The lectures pertaining to the upper school and practical science division might be given in the theatre daily at noon, between the morning examination and the afternoon lecture pertaining to the lower and middle schools, thus by judicious arrangements and construction one large theatre might serve all the requirements of a very large school, including the "want" of a large hall for occasional meetings, prize distributions, etc., demanded by the head master of the City Middle Class School, previously noticed. All practical work, such as preparing chemical and physical experiments, etc., for the lectures (which should be participated in by all the practical science sets), qualitative and quantitative analysis, exercises in the use of physical instruments and investigations, practical natural history, engineering practice, should be carried on in the chemical, physical, and biological laboratories and workshops. Such a scientific curriculum at our great schools could be carried out with advantage, so as to free our medical, military, and other special schools from much matter of a general character introductory to many departments of professional and commercial life, that now has to be given to small classes which do not, even with high fees, pay the teacher sufficiently well to allow of apparatus, specimens, and illustrations being provided on a proper scale. When the time has arrived for science-teaching in our great schools being organised on some such scheme as I have indicated, then a student, after he had gone through the lower and middle schools, should be in a position to pass the matriculation examination of the

* From 9 to 10. † From 10 to 11.

‡ It is becoming a general and judicious custom to give a whole holiday on Saturday, instead of two *half*-holidays in the week.

University of London, etc.; after he had gone through the upper school and practical science division, the examinations for the Bachelorship of Science; after he had gone through the medical school, military, naval, or technical college, etc., the Examinations for the Doctorship of Science, and attain the diploma to practise in any special calling that demands practical scientific knowledge. I believe it would be to the advantage of sound scientific teaching in the United Kingdom if a *few* schools, suited to the needs of the working, the middle, and the wealthy classes, well placed as to the active centres of professional and commercial industry, were *perfectly* organised, equipped, and officered; for such requirements demand large revenues that can only be acquired by numbers or endowments, and can never be attained to if such work is scattered among a number of schools possessed of moderate incomes, or till Government aids in the reduction of the cost of text-books, apparatus, specimens, etc., by the adoption of a definite graduated system of science teaching similar to that adopted by Continental Governments.

The aim of a school museum should be to present an open Index to Nature—ever ready for every boy to refer to at any moment he is free from the class-room and in the mood to refresh his memory on any subject he has been previously taught, or extend his knowledge on any matter he takes special interest in. Such an *index* should present to the eye, by aid of well-displayed specimens (most carefully selected for their characteristic or typical nature), models, drawings, magic lantern slides, labels, and wall decorations, *an illustrated Epitome of Nature*, giving the main headings of the constituent chapters of that great work which spreads its pages over the entire Universe; and, further, indicating the subject-matter of the subsidiary paragraphs when detailed information is sought for, more especially that bearing on the local collections. Such an index to the book of Nature (the subject-matter of which is expounded in the school lectures) should be displayed in open cases (every care being taken to indicate the inter-relation of the several volumes in which the whole vast work is bound), in a well-lighted, warm, and comfortable room, so as to be conducive to quiet study. To a description of the details of construction, arrangement, and management, I proceed in my next paper.

HOROLOGY.—III.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

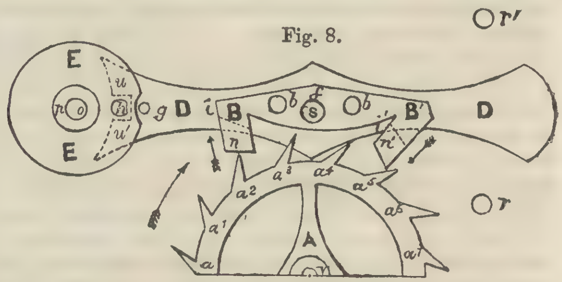
THE LEVER ESCAPEMENT.

We now proceed to describe the Lever Escapement, which, although it is more complicated in all its various modifications than any other escapements upon which we have to treat, is less costly to produce than either the chronometer or duplex, and being less delicate than both these and the horizontal, is not so susceptible to damage by careless treatment, or unskilled watchmakers, and hence less expensive in general. Our limited space will not permit us to describe every variation of this kind of escapement, we shall therefore chiefly confine ourselves to its simplest form, a description of its parts, and action of its mechanism, with a few outlines of the principal modifications and their practical results.

Fig. 8 represents the plane of one of this kind. A is the escape-wheel, mostly made of brass, carrying on its rim fifteen teeth, of which eight are here delineated—viz., a, a^1, a^2, etc. etc. It has a circular hole at v, through which passes a brass collar or collet, which unites both the arbor of the pinion and the wheel in a firm mass, this pinion being in communication or pitched to the seconds-wheel, as described in our last. B B′ is a piece of steel of the form indicated, and called the pallets (plural by reason of the individuality of its sections n and n^1). At n and n^1 there are two notches cut parallel to the plane, leaving sufficient substance to ensure stability. These notches, cut to the depth indicated by the dotted lines, are filled in with jewels of garnet or ruby, their vertical faces being slightly rounded. At s is a circular hole, through which an axle or staff, called the pallet-staff, is driven tight at right angles to the plane. D D is a piece of steel, mostly, in London-made escapements, of the form indicated, and called the lever. It is fixed firm to the pallets by the staff passing through s, and two brass pins passing through both lever and pallets at b b. At u u^1 it has a rectangular notch cut, the depth of which will be defined at a later period. g is a brass pin, put in a hole in the lever at right angles to its plane. E E is a steel disc called the roller, having a small recess or crescent cut into it opposite the pin g. At h a hole, generally circular, is drilled through this roller, and a jewelled pin, called the ruby pin, inserted at right angles to the plane of the roller. o is a circular hole, through which the axle of the balance or balance-staff is driven tight, so as to form a rigid mass; p is a projecting part of the roller, forming a steel collar or collet to give additional stability; r r^1 are brass pins inserted into one of the plates of the watch, and vertical to its plane.

The relative positions in plane will be defined later; the vertical positions or elevations are as follow:—The escape-wheel A is in plane or level with the jewels or pallet stones inserted into the pallets B B′ at n and n^1; and the lever D D is placed either above or below the pallets, according to the general build of the watch demands. The relative position of escape-wheel, pallets, and lever is determined by the shoulders of the pivots of the escapement and pallet-staff between the plates, when they are not jewelled or have single jewel-holes; and by the ends of the pivots, when they have jewel-holes and covers, that is, holes for the pivots to run through, and flat stones, covering the ones with holes, against which the pivots rest, and between which (that is, the cover to one pivot and the cover to the other) they have slight play or end-shake. The roller E E is above the lever D D, sufficient room being left between them, that no contact of their respective planes can take place. This position of the roller is again determined by the ends of the balance-staff pivots, as described above. The jewel-holes are small discs of garnet, sapphire, or ruby, set in brass collars called settings, which are in their turn let in, and screwed into the plates of frame watches for the placing of

Fig. 8.



escape-wheel and pallets, or in three-quarter plates into the plate on one side, and into a piece of brass overlapping the wheel and pallet on the other, which piece of brass is called the escape-cock. Again, the balance-staff jewelling of a frame watch (that is, a watch that has the balance above the plates) is set into two such pieces of brass, one called the potance and the other the balance-cock, both being screwed to the top plate. In the three-quarter plate or cock watches (that is, a watch with the side of the top plate cut out to give room to the balance with which it is level, or a watch having a separate cock for each wheel) the balance-staff jewelling is let into the plate, or a flat piece of brass underneath the plate on one side, and into a cock on the other. The jewel-pin, called ruby-pin, h in the roller E E, projects downward, the end reaching below the lever D D. The brass pin g in the lever is long enough to extend to the top part of the roller. The pins r r' called banking pins, fixed into the top plate of a frame watch, and into the bottom or pillar plate in a three-quarter plate watch, are extended above or below the lever.

The mechanism and its action are as follow:—The direction of the escape-wheel is indicated by the arrow, and by reason of this motion, tooth a^2 is in contact with the pallet-face n, called the driving plane, such being the position of the escapement at the moment that power is transmitted to the escape-wheel, or when the watch is wound up. The face of this pallet presents a moving incline or wedge to the direction of the tooth a^2, the pallets B B being movable about their centre or pivots of pallet staff s. Hence, a rotary motion is communicated to both pallets and lever, taking the direction indicated by the arrow. Tooth a^2 will move down this incline or driving plane n, until it

passes off into vacancy. The contact which has thus given a receding motion to section n of pallets, has also moved section n^1 about the centre s, and in the direction of the escape-wheel. When, therefore, face n ceases contact with tooth a^2, the inner surface i' of pallet section n^1 has passed within the periphery of the escape-wheel, and the escape-wheel being now disengaged of pallet section n, moves freely forward until tooth a^4 is brought in contact with i^1 of pallet n^1. This movement is called "trop," and is generally at an angular measure of one to two degrees.

We have now to conceive the wheel moved forward, and tooth a^4 in contact with i' pallet section n', in order to trace the relation between them. This inner face i' presents also a movable inclined plane or wedge to the direction of the wheel, and is so constructed that the force of the wheel draws the pallet n' towards it as indicated by the arrow, until its motion is stopped by contact of lever D and banking-pin r. The inclined face i' is called the inner locking-plane, and the vertex of the angle formed by the locking and driving-plane n', the locking-edge, and the last described position of the pallet, by reason of the contact of the tooth a^4, is called the inner locking.

We have, therefore, had a continuous rotary motion in both the escape-wheel and pallet, but under different conditions, the velocity of the escape-wheel, and the force communicated by it to the pallets, depending on the angles formed by both driving and locking-planes with the direction of the wheel.

To make these relative conditions as clear as possible, let us suppose the locking plane i' to be replaced by an arc concentric with centre s, and it will then be seen that no motion can be communicated from the wheel to the pallet. Giving now the locking plane an outward and receding inclination from this imaginary arc, it follows that, as the wheel could not have transmitted any force to the pallet, and so remained stationary while in contact with this arc, now by contact under these new conditions, a rotary motion of the pallet produces also a corresponding one in the escape-wheel, and *vice versâ*, and the force communicated by the wheel to the pallet, or the force with which the pallet is drawn towards the wheel, and the lever D held up to the banking pin r, is proportioned to the angle of the locking-plane with the pallet-radius to locking-edge, or what is the same thing, its inclination with the direction of the centrifugal force of the wheel. The faces of the escape-wheel teeth are inclined, so that contact at the point takes place only, in order to prevent contact and cohesion of two surfaces.

We will now trace the result of the pallet movement up to this point between the lever and the roller E E.

The ruby pin h passes through the notch $u\ u'$ of the lever, and in such a manner that it is perfectly free, neither sticking tight nor shaking from side to side. The pallets and lever being a rigid mass, the force transmitted to the pallets by contact of tooth a^2 and driving-plane n, is imparted by the lever to the roller through contact of the side u of lever-notch $u\ u'$ and ruby pin h, and assuming that this force is greater than the resistance of the pendulum-spring, the lever moves in the direction indicated by the pallets, and so imparts rotary motion to the roller E E. The ruby pin remains in contact with the notch of the lever, till the motion of the latter is arrested by pin r. The contact of lever and roller is conditional to two intersecting arcs described between their respective centres, the radius of one being expressed by the distance of lever-centre s to end of lever-notch $u\ u'$, and that of the other by the roller radius to centre of ruby pin h. The length of lever arc being determined by the banking-pins $r\ r'$, the position of the end of the lever-notch must be at the same distance from the line of the two centres, as the point of intersection of two arcs, to give free exit to ruby pin h at the moment when the lever is arrested by banking-pin r.

We will now consider that the escapement was in the position our diagram illustrates at the instant the winding took place, after which, impulse being communicated by the rotary motion of tooth a^2 on driving-plane n to the roller, through contact of ruby-pin h and lever-notch, the balance received sufficient momentum to continue its vibration after it makes its exit out of the lever notch. During this part of its vibration it is totally detached from the rest of the escapement, hence its title, "detached escapement." The momentum thus imparted to the balance being expended as before explained, a new and return motion takes place, the result of which on the escapement we have next to trace. It will be remembered that the lever is held in its position of rest against the pin r by the contact of tooth a^4 and locking-plane i', and therefore the lever-notch is where the pin h left it at the point of its exit; and hence the same conditions that permitted its exit will also allow its entry.

Considering that at the moment of entry into the lever-notch the last is in rest and the roller in motion, we have the changed conditions of the roller, which is simultaneous in its motion to the balance, giving movement to the lever; the conditions under which such takes place we have next to point out.

As the lever is held to the banking-pin, r, by the rotary force of tooth a^4 in contact with locking-plane i', it follows that the force giving motion to the lever, D D, must be greater than the resistance, which force is lodged in the balance momentum and the pendulum-spring. We will take the position of the point of tooth a^4 at an angular measure of $2°\ 30'$ from the locking-edge, or rather say the position of the locking-edge within the periphery of the escape-wheel is equal to $2°\ 30'$, measured from its own centre. As we have seen that the result of the locking of the pallets by the escape-wheel has been a forward motion of the latter, and to the amount of the difference of the deviation of the locking-plane i' from an arc described from the locking-edge, and with its radius to the angular point stated above, so must now to the same amount the escape-wheel be brought back again, which return motion of the escape-wheel is called a recoil; from which we gather that the greater or firmer the locking, the greater the resistance to the balance when the unlock- or relieving takes place, which being at the expense of the balance momentum, is the evil we have referred to in our last article. This balance resistance by unlocking is equal to the quotient of the product of pallet-radius of contact, cosine of the angle formed by i' with pallet-radius, and centrifugal force of wheel, divided by the product of balance momentum, pendulum-spring force, and lever and roller radii ratio.

We see from this definition that the roller-pin has to push the lever before it, until the locking-edge of pallet n' is in the periphery of the escape-wheel, when a total change of conditions takes place again.

The locking-edge being the vertex or climax of two inclined planes, i' and n', the moment this is reached and passed, that is, the moment this edge has passed outside the periphery of the wheel, tooth a^4, by its latent rotary force, passes on to the driving-plane n', when the attractive effect is momentarily changed into a repelling one, by which the resistance to the balance and contact of ruby pin h and side u' of lever-notch $u\ u'$ ceases, and the contact of the side u and opposite part of pin h commences, and impulse is again imparted by the contact of tooth a^4 on the driving-plane n', thus giving motion to the lever; the angular motion of this impulse being again proportioned to the inclination of n' with the direction of the centrifugal force of the wheel which is the tangent to the radius of contact.

When tooth a^4 has arrived at the end of the driving-plane n', called the outer delivery edge, and their contact again ceases, by the simultaneous motion of pallet n, the edge of face i of pallet n has in its turn passed within the periphery of the escape-wheel, and being inclined at the same ratio as locking-plane i, locking again takes place. The pallet n, by contact of tooth a' and the outer locking-plane i, is driven towards the wheel, until its motion is arrested by banking-pin r'; and the ruby pin h, making its exit out of the notch $u\ u'$, allows the balance to complete its vibration, after which, with its return vibration a repetition of the action just described occurs, as long as the escape-wheel is rotated by the preceding wheel, and so on.

We will now take the relative position in plane of wheel and pallets, lever and roller, and the former two to the latter two, into consideration; and for this reason go back again to the position of the escapement in our diagram. Following up the passage of tooth a^2 on driving-plane n, the moment arrives when the escape-wheel passes off. As we have seen that according to the position of the point of tooth a^4, being on locking-plane i' or driving-plane n', so in the first case the pallet is attracted and in the second repelled; the position of the locking-edge of pallet n', at the instant the contact of tooth a^2 and driving-plane n ceases, determines either one or the other. If it be within the periphery of the escape-wheel, locking takes place as described; if without, so will, according to its position outside the periphery, tooth a^4 pass on to the driving-plane n',

instead of first on to the locking-plane i', and from thence on to the driving-plane n'. The result of this is that pallet n' is immediately repelled, and contact of side u' and pin h of lever-notch changes to contact between h and side u, and the balance momentum receives a check; and if the action proceeds, the balance continuing the movement of the lever by the expending of its momentum and force of pendulum-spring, has to force the escape-wheel back on the same conditions and disadvantages as the unlocking is effected, until the locking-edge of pallet n' has passed the periphery of the escape-wheel, and locking takes place. Other errors connected and arising out of this we will point out presently. As we have already stated the evils arising out of a necessary amount of locking, it is not necessary to say more than that the relative position of the wheel and pallet centres should be such that the locking-edge of either pallet is within one degree, angular measure, of the periphery of the escape-wheel, when the driving-plane of the opposite pallet becomes disengaged. For the information of practical experimentalists, I may add that in most cases of fair-proportioned pallets, the distance from the outer locking to the outer delivery edge of the pallets will give the distance of the two centres. Now, as regards this proportion. We have seen that the escape-wheel teeth become disengaged as the delivery edge of either pallet passes beyond its periphery. But as the locking-plane of one pallet has passed, say one degree within the periphery of the escape-wheel, before the delivery-edge of the opposite pallet has passed this point, it follows that, when the unlocking takes place, the delivery-edge of one pallet must pass also one degree within the periphery of the escape-wheel, before the tooth becomes disengaged from the locking-plane, and passes on to the driving-plane of the opposite pallet. During this angular movement of penetration, the escape-wheel is not stationary, but is recoiling, as we have shown in the unlocking, and hence it will be seen that there must be a certain amount of space or clearance between the delivery-edge and the back of the tooth, or the former will come in contact with the latter, by which the motion of the pallet would be arrested, and the watch would stop. This clearance is synonymous with the drop, which is, therefore, a necessary condition. This drop in proper proportioned pallets is equal off both delivery edges. If the pallets are large, we get more drop off the inner delivery edge, and if small, more drop off the outer delivery edge in proportion to the other; but whether they are both equal or not, there must always be sufficient to prevent the delivery edge of either pallet coming in contact with the back of the tooth on its return motion.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLVI.—JOSEPH CLEMENT.

THE inventor of the planing-machine, the steam-whistle, and many other useful contrivances, Joseph Clement, was born at Great Ashley, in the county of Westmoreland, in the year 1779. Though but a humble hand-loom weaver, his father proved a man of remarkable culture, became an ardent student in natural history, and attained a degree of knowledge in that science which could scarcely have been looked for in a mere working man. Entomology, the science which treats of insects, was the department to which he always applied himself in his earlier years, and his hours of leisure were chiefly devoted to searching the hedge-bottoms for beetles, flies, and so forth, until he had formed a very complete and interesting collection.

Joseph, his son, like the children of the poor, was early put to work; hence he received but little education. At the village school he acquired the simple rudiments of reading and writing; the rest of his education he gave himself, in after years. At the hand-loom his father required all his assistance, and for some years they worked together; but as the loom was gradually giving place to improved machinery, his father resolved to devote his son to a better trade than that of weaver.

"They have a saying in Cumberland," writes Mr. Smiles, "that when bairns reach a certain age, they are thrown on the house-rigg, and that those who stick on are made thatchers of, while those who fall off are sent to St. Bees to be made parsons of. Joseph must have been one of those who stuck on—at all events, his father made him a thatcher, afterwards a slater, and he worked at that trade for five years, between eighteen and twenty-three."

Like his father, Joseph Clement had a liking for mechanics, and in the long nights of winter he had plenty of time to follow the bent of his tastes. In the village blacksmith, whose premises he was wont to frequent, he found a friend who permitted him to use his tools, and there, as a volunteer workman, he learned to work at the forge, to handle the hammer and file, to weld iron, and to shoe horses, which he could do with equal care and expertness.

Some works on mechanics that were lent him by a cousin, who about this time returned from London to their native village, kindled in young Clement the desire to become a regular mechanic rather than a slater, yet he continued to maintain himself in the latter capacity, until his skill was further cultivated, and then he determined, with the assistance of his friend the village smith, to make a turning-lathe.

The latter was found to work most successfully, and he proceeded to turn fifes, flutes, clarionets, and other instruments, on all of which he had taught himself to play; his crowning effort being the production of a set of bagpipes, on which he performed to the delight and astonishment of the whole village. Aided by the descriptions which he found in the books lent by his cousin, this natural genius made for his father a microscope to assist him in his entomological studies; and next he succeeded in constructing a reflecting telescope.

In the year 1804 we find him turning his attention to the making of screws; "and he proceeded to make a satisfactory pair of die-stocks, though it is said that he had not before seen or even heard of such a contrivance for making screws." Though frequently urged by his father to "stick to slating as a safe thing," his own desire was to rise in mechanics, and he resolved to leave his secluded village in the north country, and seek work in some new line.

At Kirkby Stephen he succeeded in finding some employment in a small factory, where he worked at making power-looms. This place is a small market town in Westmoreland pleasantly situated on the west bank of the Eden at the foot of Ash-fell, and yet consists of only one street, where the woollen manufacture is carried on, and most of the inhabitants are employed in stocking-knitting. There, in partnership with a man named Andrew Campbell, he was employed in piece-work, in supplying materials and workmanship for looms, shuttles, and models; and there he sold his reflecting telescope for the sum of £12.

In 1806 he removed to Carlisle, where for two years he was employed by the Messrs. Forster and Son in the same description of work he had followed at Kirkby Stephen, and from Carlisle he proceeded to Glasgow, where he procured employment as a turner, and took lessons in drawing, from Mr. Peter Nicholson, an ingenious and well-known writer on carpentry, an author who wrote in conjunction with Mr. Telford the engineer. Happening to visit the shop in which Clement was at work, in order to make a drawing of a hand-loom, Nicholson was so pleased by the young mechanic's praise of his performance, that he inquired if he could be of service to him in any way. Clement replied, that the greatest favour he could bestow upon him would be a loan of the drawing he had just made. This "request was at once complied with; and Clement, though very poor at the time, and scarcely able to buy candle for the long winter evenings, sat up late every night, until he had finished it." His copy was so close, though the first drawing he had ever attempted, that Nicholson became proud of such a pupil, and generously offered to give the young Englishman gratuitous lessons, which were gratefully accepted, and in a short time he became a most expert draughtsman.

From Glasgow Clement next proceeded to Aberdeen, where he ultimately earned three guineas weekly as a designer and maker of power-looms; and there he constructed a turning-lathe, with a sliding mandril and guide-screws, for cutting screws, furnished also with the means for correcting guide-screws. "In the same machine he introduced a small slide-rest, into which he fixed the tool for cutting the screws—having never before seen a slide-rest, though it is very probable he may have heard of what Maudslay had already done in the same direction."

While at Aberdeen, he would seem to have attended the lectures on Natural Philosophy in the Marischal College during the year 1812. In the following year, having by thrift and care saved £100 out of his hard-won wages, he resolved to proceed to London, and the old stage-coach by which he travelled south —an outside passenger, no doubt—set him down at Snow Hill, London. There he found himself without a friend. Ere he turned away, he asked the guard of the coach whether he knew of any person "in the mechanical line in that neighbourhood?" "Yes," replied the guard; "the shop of Andrew Galloway, a Scotchman, is just round the corner."

Hurrying there, Clement saw in the window several lathes and other machines, and the next day he at once obtained employment, for in those times a man who could use his pencil was deemed a very superior mechanic. Finding all Galloway's tools of an inferior kind, Clement's first work was to make a complete set for himself to the surprise of his fellow-workmen, who loudly praised the expertness and intelligence he exhibited; but as a guinea per week was all that he could earn in the employment of Galloway, an old workman recommended Clement to offer himself to Bramah in Pimlico, adding that "he was always on the look-out for first-rate mechanics."

At Pimlico he was engaged for three months, at two guineas per week. He was placed in charge of the tools of the shop; and showed himself so expert at the introduction of improvements, and the general organisation of work, that Joseph Bramah made him a handsome present, and on the 1st of April, 1814, made a formal agreement with him, for the term of five years, "during which he undertook to fill the office of chief draughtsman and superintendent of the Pimlico Works, in consideration of a salary of three guineas a week, with an advance of four shillings a week in each succeeding year of the engagement."—(Smiles.)

"If I had secured your services five years since," said Bramah, "I should now have been a richer man by many thousands of pounds."

On the death of Bramah, his sons returned from college and entered into possession of the business. "They found," says the author of "Industrial Biography," "Clement the ruling mind there, and grew jealous of him to such an extent that his situation became uncomfortable, and by mutual consent he was allowed to leave before the expiry of his term of agreement. He had no difficulty in finding employment, and was at once taken as a chief draughtsman at Maudslay and Field's, where he was of much assistance in proportioning the early marine engines, for the manufacture of which that firm was becoming celebrated. After a short time he became desirous of beginning business on his own account."

In this idea he was encouraged and fostered by Hugh Duke of Northumberland, who was a great lover of mechanics, and being a capital turner, used often to visit Maudslay's, and thus became acquainted with Clement, who having saved £500, started a small workshop in Prospect Place, Newington Butts, and there in 1817— the year in which Duke died— he began business as a mechanical draughtsman and manufacturer of machinery. He was soon confessed to stand unrivalled as an artist in mechanics, and his pencil attained a truth in perspective which has not yet been surpassed. He invented an ingenious instrument, by which ellipses of all proportions, as well as circles and right lines, might be geometrically drawn on paper or on copper, and for this the Society of Arts awarded him their gold medal in 1818.

In that year he furnished the lathe with a slide-rest for the purpose of cutting screws, twenty-two inches long, and provided with the means of self-correction; and in 1827 the Society of Arts awarded to him their gold Isis medal for his improved turning-lathe, which embodied many ingenious contrivances, all calculated to increase its precision and accuracy in large surface-turning; and in the following year, having added to it his self-adjusting double-driving centre-chuck, he received the silver medal. In 1828 he also began the making of fluted taps and dies, and established a mechanical practice with reference to the pitch of the screw which proved of the greatest importance in the economics of manufacture.

He next invented the screw-engine lathe, with gearing, mandril, and sliding-table wheel-work, by means of which he cut the inside screw-tools from the left-handed holes; while in shaping machines he was the first to use the revolving cutter attached to the slide-rest. A description of his planing machine would far exceed the limits of this paper. He was employed by Mr. Babbage to make his celebrated calculating or difference engine, a "machine of so complicated a character, that it would be impossible for us to give any intelligible description of it in words." He also made the steam-whistle, for Brunel's locomotives on the Great Western Railway, and when mounted, "the effect was indeed screaming—they were heard for miles off."

One of the last works made by this most ingenious man was an organ for his own use. It cost him £2,000 for labour alone. When young and poor, and working as a slater, he had excelled in making flutes and bagpipes; and when old and wealthy, his organ became his pet hobby. Clement, we are told, was a heavy-looking man, with an unpolished manner, and never forgot, to the last, his strong Westmoreland dialect. He died in 1844, in the sixty-fifth year of his age.

AGRICULTURAL CHEMISTRY.—XII.

BY CHARLES A. CAMERON, PH.D., M.D.,

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CHAPTER XII.—ANIMAL CHEMISTRY.

A MOST important branch of rural economy is the production of animal food—that is, the conversion of vegetable substances into beef, mutton, and pork. The problem which each feeder has, or at least should try, to solve is—How is the largest quantity of meat to be produced from the smallest amount (in value) of food? It is a great help to the stock-feeder when he brings to the consideration of this question a knowledge of the chemical properties of food substances, and of the physiology of the animals of the farm; but in addition to this scientific knowledge he must also possess that special, or practical information which is the result of experience acquired in the feeding-house and the food markets. Analyses of vegetables are valuable, because they show the different proportions of starch, fat, albuminates, and other alimentative principles which they contain; but in comparing the composition of two kinds of feeding materials we must not invariably conclude that because one of them is richer in nutritive materials than the other, it is necessarily more valuable as food. For example, rape cake is somewhat richer in oil and albuminates than linseed cake, but the latter is found by experience to be the better food. Rape cake possesses in general a somewhat acrid flavour, and it is not so highly relished or so readily digested as linseed cake, and hence its relative inferiority. In fact, flavour, digestibility, and suitability, in the case of the animals fed upon it, are factors which, as well as composition, must be taken into account in determining the nutritive values of food substances. In general, however, we glean from the analysis of foods much information of a practical nature; and when we find that two kinds of food appear to be equally enjoyed and digested by animals, then we may safely leave the question as to their relative values to the decision of the chemist.

The food consumed by animals is chiefly disposed of in maintaining the heat of their bodies, and in sustaining the movements of their organs. If we burn fat, or starch, or sugar, it produces heat; and by the combustion of food beneath the boiler of a steam-engine, force, or motion, is developed. Now the temperature of an animal is often nearly 100° higher than that of the atmosphere surrounding it, and this temperature is kept up solely by the slow combustion of a portion of its food or body. An animal, too, roams about in quest of its food, its blood circulates throughout its body, and its heart, lungs, and other internal organs are incessantly in a state of *activity* or motion. These different movements of the body are carried on by means of the force set free by the slow combustion of food in the animal's body.

It is a vexed question whether animal heat and motion are derived from the combustion of food (partially digested), the blood, or the solid tissues (muscles, fat, etc.); but this matter is not one of importance to the stock-feeder. It is also a disputed point whether or not animal motive power is derived chiefly from nitrogenous or non-nitrogenous foods. Liebig believes that the fats, sugars, starches, and other non-nitrogenous matters (carbohydrates), are expended in keeping up the temperature of the body, whilst the nitrogenous constituents of food (the albuminates

or albuminoids) are used for the purpose of repairing the animal mechanism, and developing *energy*, or motive power. On the other hand, Mayer, Voit, Fick, and Wislicenus, Frankland, E. Smith, Haughton, and other eminent authorities, assert that not only the heat of the body, but also its energy, are chiefly maintained by the fatty portion of food. They assert that during activity the muscles increase in weight instead of diminishing, whilst under prolonged exertion the fatty tissue rapidly diminishes in quantity. The results of some interesting experiments recorded by Dr. Austin Flint of New York, in 1870, in a work entitled "The Physiological Effects of Severe and Protracted Muscular Exercise," are in favour of Liebig's views, whilst Dr. Parke's investigations appear to show that the truth lies, as is so often the case, between the theory of Liebig and that opposed to it.

The question whether the nitrogenous or the non-nitrogenous food materials are the most important agents employed in sustaining the heat and motions of the body is of practical importance to the stock-feeder. When animals are fed upon grass, hay, and roots, these articles, no doubt, supply, in properly balanced proportions, all the substances required for the nourishment of the body; but when "artificial foods" are purchased the question arises, Which are the most economical and suitable? those which are rich in fat, or those which contain abundance of nitrogen? Some years ago the value of a food substance was measured by the amount of nitrogen which it contained; and the oil cakes were believed to owe their highly nutritious properties to their large per-centage of albuminates. There is, however, but little doubt that it is the fat which exists so abundantly in linseed and rape cake that chiefly renders those foods so valuable. In the case of oxen, sheep, and pigs, the most valuable foods are those richest in palatable fats and oils; whilst for horses and other working animals a diet somewhat less oleaginous is more economical. In the case of young animals, a diet rich in albuminous substances is necessary, for whilst starch, sugar, and fat may fully maintain the heat and energy of the body, its muscles can only be repaired by the albuminates.

We append in a tabular form at the end of this paper, the results of the elaborate experiments of Messrs. Lawes and Gilbert, showing the composition of the three most important animals of the farm which are used as food for man.

On an average the pig consumes daily from 26 to 30 pounds weight of food for every 100 pounds of its own weight, the sheep about 15 pounds and the ox from 12 to 13 pounds. The pig stores up in "permanent increase" (that is, incorporates permanently with its body) about 20 per cent. of the weight of its food, excluding the water which the latter includes. Sheep retain 12 per cent. of the weight of their (dry) food. The relative increase of the nitrogenous, fatty, and mineral constituents of the carcases of oxen, sheep, and pigs is shown in the table:—

Cases	Estimated per cent. in Increase whilst Fattening.			
	Mineral matter (ash).	Nitrogenous matter (dry).	Fat (dry).	Total dry substance.
Average of 98 oxen .	1·47	7·69	66·2	75·4
Average of 348 sheep	1·80	7·13	70·4	79·53
Average of 80 pigs .	0·44	6·44	71·5	78·40

A very large proportion of the food consumed by animals is expended in keeping their bodies warm. The colder the atmosphere is the greater is the quantity of food consumed in maintaining the temperature of the blood up to 100°. In the case of man, clothes are a partial substitute for food. The naked body parts readily with its heat, which radiates from the skin into the air. Clothes are a bad conductor of heat—*i.e.*, heat does not readily pass through them; therefore, when the body is clothed, a wasteful expenditure of heat is prevented, and the necessity for heat-giving food is diminished. The hair, fur, and feathers of animals subserve, amongst other purposes, that of preventing too rapid an escape of heat from the body. Notwithstanding the covering with which nature has furnished the bodies of the lower animals, they often die from exposure to intense cold. The farmer should not allow his stock to be exposed to much cold during the winter and early spring, and he should carefully protect them from the influence of cold winds. Young animals are less able to resist cold than adults, and therefore young stock should not be allowed to remain in the fields during the whole winter, as is sometimes the case in various parts of the British Islands.

Oxen, when fed in stalls, fatten more rapidly and consume less food if kept in a temperature of from 75° to 90° Fahr. It is, however, difficult to keep a feeding-house highly heated and well ventilated at the same time, and it is better to have a cool and well-aired stall than a hot and badly ventilated one.

Summary of the Composition of the Ten Animals, showing the Per-centages of Mineral Matter, Dry Nitrogenous Compounds, Fat, Total Dry Substance, and Water.

1st. In Fresh Carcase. 2nd. In Fresh Offal (equal Sum of Parts, excluding Contents of Stomachs and Intestines). 3rd. In Entire Animal (Fasted Live-weight, including therefore the weight of Contents of Stomachs and Intestines).

Description of Animal.	Per cent. in Carcase.					Per cent. in Offal.					Per cent. in Entire Animal.					
	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Contents of viscera.	Water.
Fat calf	4·48	16·6	16·6	37·7	62·3	3·41	17·1	14·6	35·1	64·9	3·80	15·2	14·8	33·8	3·17	63·8
Half-fat ox	5·56	17·8	22·6	46·0	54·0	4·05	20·6	15·7	40·4	59·6	4·66	16·6	19·1	40·3	8·19	51·5
Fat ox	4·56	15·0	34·8	54·4	45·6	3·40	17·5	26·3	47·2	52·8	3·92	14·5	30·1	48·5	5·98	45·5
Fat lamb	3·63	10·9	36·9	51·4	48·6	2·45	18·9	20·1	41·5	58·5	2·94	12·3	28·5	43·7	8·54	47·8
Store sheep	4·36	14·5	23·8	42·7	57·3	2·19	18·0	16·1	36·3	63·7	3·16	14·8	18·7	36·7	6·00	57·3
Half-fat old sheep ...	4·13	14·9	31·3	50·3	49·7	2·72	17·7	18·5	38·9	61·1	3·17	14·0	23·5	40·7	9·05	50·2
Fat sheep	3·45	11·5	45·4	60·3	39·7	2·32	16·1	26·4	44·8	55·2	2·81	12·2	35·6	50·6	6·02	43·4
Extra fat sheep ...	2·77	9·1	55·1	67·0	33·0	3 64	16·8	34·5	54·9	45·1	2·90	10·9	45·8	59·6	5·18	35·2
Store pig	2·57	14·0	28·1	44·7	55·3	3·07	14·0	15·0	32·1	67·9	2·67	13·7	23·3	39·7	5·22	55·1
Fat pig	1·40	10·5	49·5	61·4	38·6	2·97	14·8	22·8	40·6	59·4	1·65	10·9	42·2	54·7	3·97	41·3
Means of all	3·69	13·5	34·4	51·6	48·4	3·02	17·2	21·0	41·2	58·8	3·17	13·5	28·2	44·9	6·13	49·0
Means of 8 of the half-fat, fat, and very fat animals...	3·75	13·3	36·5	53·6	46·4	3·12	17·4	22·4	42·9	57·1	3·23	13 3	29·9	46·4	6·26	47·3
Means of 6 of the fat, and very fat animals	3·38	12·3	39·7	55·4	46·6	3·03	16·9	24·1	44·0	56·0	3·00	12·7	32·8	48·5	5·48	46·0

HOROLOGY.—IV.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

THE LEVER ESCAPEMENT (*continued*).

We will now proceed to consider the conditions of roller and lever contact, or roller depth. We have seen that the position of the lever-notch and the exit of the pin therefrom takes place when the lever rests against either one or the other banking-pin, and we have also seen that impulse is imparted by contact of either side of the lever-notch with the ruby-pin h (see Fig. 8, page 364). Suppose now that the drop of an escape-wheel tooth on to either locking-plane, and contact of lever and either banking-pin was at the same angular point, it will further be seen from what has been said that the length of lever-notch must be so adjusted that the pin g is liberated therefrom.

Conceiving now the balance to return and to effect the unlocking, we see that such will be accomplished before the pin has entered the notch, so as to permit a fair contact between either side of the notch and the pin; and hence for this reason, it is obvious, in order that the pin may fairly enter the notch before impulse commences, the notch should be sufficiently long. This, however, could not be the case in the last given condition of lever and banking-pin contact, because, if it were so, the pin could not leave the notch; hence we require an angular movement of some one or two degrees after the wheel is disengaged.

There is, however, one other reason for such, which brings me to speak respecting the connection of the pin g, called the "guard-pin," and the circumference of roller.

If we suppose the lever at rest against either banking, and the pin h out of the notch, we can easily conceive that, if by any occurrence the lever should change position to the other banking, the ruby-pin in returning, instead of entering the notch, would strike the back of the lever, and the watch would stop. To prevent this error the guard-pin g is contrived, and its office is as follows:—Supposing that under the circumstances last described, any force endeavoured to misplace the lever, the pin g would thereby come immediately in contact with the circumference of the roller, and by contact of an escape-wheel tooth with either locking-plane, would bring the lever back again to the banking. In the course of the action of the escapement, the pin g never comes in contact; and in order to prevent the slightest contact taking place, the crescent is cut into its circumference as shown in the diagram. The pin must therefore be at such a distance from the roller that there is a certain amount of play; but that has its maximum, and should never be so much as to allow either locking-edge of the pallet to pass the periphery of the escape-wheel, the effect of which would be that the escape-wheel tooth, passing on to the driving-plane and repelling the pallet, would thereby press the guard-pin against the edge of the roller, and stop the watch. The guard is safest when the ratio of radius of roller circumference and radius of guard-pin g is at a minimum; hence, to bring the position of the pin as forward as possible, the face of the ruby-pin is often flat, in order to avoid the necessity of a deep notch in the lever.

In order, therefore, that there be sufficient freedom between guard-pin and circumference of the roller without producing this error, it is further necessary, in addition to such being required by the roller depth, that there should be a small angular movement after disengagement, or locking and banking contact. The angular position of the pallet also requires attention. The roller-depth requires, as I think will be easily seen from what has been said, that the lever should move just as far from one side of the line of centres as it does on the other, before it banks against r and r'.

In relation to this motion, the pallets require to be placed on the lever so that we have the same angle of locking penetration on one side and the other, that is, the locking-edges are alternately the same distance from the centre of the wheel when the teeth become disengaged; otherwise, we have an excess of locking on one side, and on the other the evil and its result of the drop and banking at the same moment.

The driving-planes n and n' are variously constructed, to give an angular impulse motion to the pallets from 7° 30′ to 12°, the former being applied to best watches, and the latter to common, as not requiring such careful and close adjustment. The impulse-arc of the balance is variable from 30° to 45°, and is determined by the radii of lever and roller. The former is to the latter as the sine of the angle formed by the latter with the line of centres is to the sine of the angle formed by the former with the line of centres. On an average, the following short rule will suffice:—Take a piece of thin brass, and drill two holes at the same distance as the balance and pallet centres; divide the distance in four parts; take one part as the radius of the ruby-pin, and the other as the distance of lever to notch, plus the half thickness of ruby-pin to be used.

We will now briefly state a few modifications.

The principal modification is the "club-tooth." The driving-plane is divided, and half given to the tooth, the advantage of this being that little or no drop off the delivery is necessary, because the tooth, being thick or broad, can be hollowed out for clearance. Another consists in a wheel carrying the whole locking and driving-planes, and the pallets consisting of two fine long teeth in some cases and pins in others. The advantage here is that contact is continually given at the same distance from pallet centre, which is not the case in other pallets. Another modification, called "Cole's resilient," consists in the bending of the extreme points of the teeth back, the wheel going or rotating reverse to others, by which the banking is effected against the front of the teeth, and the guard-pin dispensed with.

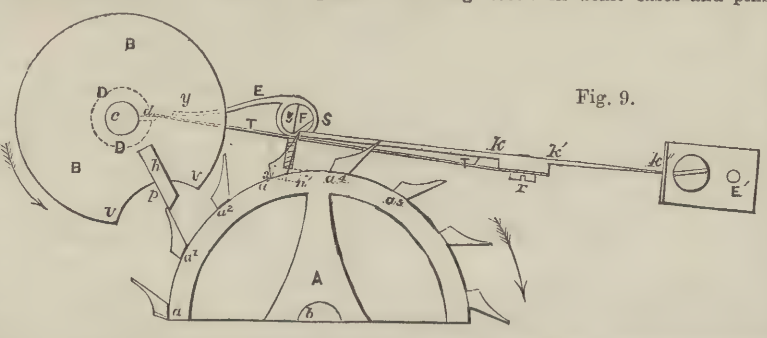


Fig. 9.

The principal modification of the roller-action is the double roller. It is found of advantage to have a short balance arc of impulse, which is effected by increasing the ratio of lever and roller radii. By this, however, the guard-pin contact becomes unsafe in proportion to their respective radii, and hence an extra roller is applied for the guard only.

Another modification, of a number, is the two-pin action. By this the guard-pin gives impulse also by a fine square notch in the circumference of the roller, a pin being drilled on each side of the roller-notch to effect the unlocking. By this arrangement we get a maximum impulse with a minimum resistance, which, if carefully adjusted, is an excellent modification.

Others might be mentioned, and many points more clearly and extensively treated, but the limited space at our command obliges us to proceed at once to

THE CHRONOMETER ESCAPEMENT.

In our second article we have given the outlines of the conditions on which the relative merits of the escapements depend, and it is unnecessary now to speak on this point again. Therefore we shall proceed with the chronometer escapement in the same way in which we treated the lever—viz., with a description of its sections and the action of its mechanism.

In Fig. 9 A is the escape-wheel, with fifteen teeth on its rim, a, a^1 a^2, and so on, with a circular hole at b for securing its position on the escape-pinion in the same manner as the lever escape-wheel is fastened. B B is a steel roller, called the impulse-roller, of the same thickness as the escape-wheel teeth, and fixed firmly on to the balance-staff, which passes through a circular hole, at c. The circumference of this roller is broken by a crescent, v v, whose chord is about that of two teeth of the wheel. The arc of this crescent is further broken by a

rectangular notch, with which a jewel, h, called the impulse-pallet, is connected. The face, p, of this pallet is rectilinear with the radius of the roller, in whose circumference its extreme point lies.

Beneath this roller, and fixed to the balance-staff in the same manner, is a second roller, called the discharging or relieving roller, as delineated by the dotted circle D D. This roller also has its circumference broken by a rectangular notch, into which a jewel, d, called the discharging or relieving pallet, is inserted. The face of this pallet points in the opposite direction to the face, p, of the impulse-pallet, h, and is also rectilinear with the radius of the roller. This pallet projects beyond the roller circumference to about one-third its radius.

E E′ is a spring of steel, called the detent, as delineated in the diagram. At E′ it is screwed to the pillar-plate, as is the case in a three-quarter-plate movement, or to a stud in a frame movement. At s it is of the shape of a hollow cylinder, leading off on one side into the curved part E y, and on the other into the straight stem $s\ k$.

$k'\ k''$, which is the continuation of $s\ k$, is reduced to a very thin spring. The section E y, $s\ k$ is also reduced to an approximation of a spring. At r an elevation or projection is left, upon which a gold spring, called the discharging or relieving spring, T T′, is screwed, the opposite end of which is resting upon the end E y. The strength of this spring is also reduced to a minimum, except the end at y, which is left slightly swelling. Into the hollow of the cylindrical part of the detent, at s, is a jewel, F, inserted, called the detent-pallet. One-half of this hollow is filled up by this pallet, and the other half by a steel or brass plug, by which the pallet is secured. At n is a screw called the stop-screw, passing through a stud and meeting the cylindrical section of the detent.

The vertical position or elevation of this escapement is as follows :—The rim and inner part of the escape-wheel A is sunk below the plane or level of its teeth, or, in other words, the teeth of the escape-wheel are level with the rest of the wheel on the bottom, but raised above it on the top, giving thereby broad teeth, without, at the same time, giving a massiveness to the wheel and so increasing its inertia, which in all parts of every escapement should be at a minimum, in so far as necessary stability will permit.

The roller B B is in the plane of the escape-wheel teeth, or level with it at top and bottom, and therefore of the same thickness; and the impulse-pallet h is also in the same plane, and therefore as broad as the roller is thick.

The detent E E′ is placed below the escape-wheel, but no lower than to give sufficient clearance, and so avoid contact. The plug g is also level with the top of the detent, but the detent-pallet F projects to the tops of the escape-wheel teeth. The lower part of the detent is reduced from y to the cylinder at E, and again from s to k, leaving the cylinder with the pallet F and plug g projecting below and terminating together. From k' to k'' the spring is left, and hence level with the projecting cylinder. At k'' there is a step, leaving it of sufficient thickness to give it a firm seat between the plate and head of the screw. The discharging spring covers the detent at $k\ k'$, but is reduced from k to y, and on a level with the recesses of the detent. The end of the detent E y, its stem $k\ s$, and the discharging spring from k, are therefore on the same level top and bottom, and as much below the impulse-roller B B as the detent is below the escape-wheel.

The discharging-roller D D, and its pallet d, are in the same plane as the end of the detent; sometimes, by reason of its thickness, it projects a little above and below. The stop-screw n lies below the discharging-spring, leaving a clearance between it and the spring, but not lower than the cylindrical section of the detent, the projection of which depends upon the general build of the watch. The position both of the balance and escape-wheel is secured by jewellings, as described in the lever escapement.

We shall again adopt our former method, and describe the action of its mechanism before we treat on the relative positions in plane and ratios of its sections.

Our illustration shows the escapement in repose, or the relative rotary positions when the watch is not wound up. Supposing now the winding effected and force transmitted to the escape-wheel, and we will trace the result.

The escape-wheel is moving in the direction indicated by the arrow. Tooth a^1 is in contact with the face p of pallet h. Discharging-pallet d of roller D D is likewise in contact with the end of discharging-spring T T′. By reason of contact of tooth a^1 and impulse-pallet h, the roller B B turns about its centres until the point of intersection of the arc of contact of escape-wheel and roller is reached (see description of roller and lever action of last escapement), when contact ceases, and the escape-wheel is released.

The detent E E′, when by reason of the rotary position of discharging-pallet d contact has ceased, rests by the projecting cylinder against the stop-screw n, which is so adjusted that the detent-pallet F penetrates the periphery of the escape-wheel measured from k'' by one to two degrees. As both the impulse and discharging rollers are fixed on the balance-staff, it follows that both rotate together, and hence pallet d is moving in the same direction as pallet h during contact with tooth a^1, and so with the latter is progressive in contact with discharging-spring T T′, and under the same conditions. The length of this discharging-spring in relation to its centre of motion (such lying between k' and k'' during its motion in this direction) is so adjusted that contact between it and discharging-pallet d ceases, and the detent returns to its repose before the escape-wheel becomes disengaged from the impulse-pallet h. And so, when it is relieved, detent-pallet F, having taken its position within the periphery of the escape-wheel, in its turn receives the contact of escape-wheel tooth a^2. Each roller being now wholly disconnected from the escape-wheel or detent (hence its title, "detached"), proceeds on its vibration, as explained in the lever escapement. Supposing such completed, and a new one, bringing discharging-pallet d again in contact with discharging-spring T T′, we will next trace this result.

The end y of the detent lies beyond the circle of discharging-pallet d, and hence no contact between this and the detent takes place directly, but only through the discharging-spring T T′. Such being the case now, this spring is bent away from the detent, and in the direction that the latter cannot follow, being prevented by the stop-screw n. The condition of contact of discharging-pallet d and spring T T′ is that of two intersecting arcs, as in the wheel and roller; and hence, when the point of bisection is passed, contact ceases, and the discharging-spring returns to its position of rest against the end y of the detent, and the vibration of the balance proceeds.

We see by this that in the return motion of the balance the chief part of the escapement remains in repose, contact only taking place during a short arc between the discharging-spring and pallet.

Again the balance commences a new vibration, which brings the pallet d in contact with the discharging-spring T T′. But now the conditions are changed, and we have the same effect as if this spring and the detent were a solid piece. Resting against the projecting part y, the detent is acted upon immediately contact takes place from this direction. By the momentum of the balance the detent is moved, and its spring $k'\ k''$ comes into action. By this movement of the detent, the detent-pallet F is moved away from the escape-wheel, which is released the moment its periphery is passed.

The relative angular positions of the discharging and impulse pallets is such that the pallet h has penetrated the periphery of the escape-wheel about one degree, measured from its own centre, when the tooth a^2 (which we conceived to be in contact with pallet F) becomes disengaged, and so the pallet h is in position to receive contact of the next tooth a, when the impulse goes on as our illustration shows it, and as we have already described.

It will be observed that we have in this escapement only one impulse every second vibration, but as then the escape-wheel makes an angular motion equal to the measurement from one tooth to the other, the number of the balance vibrations are two to every tooth.

The balance resistance lies in the contact of the discharging-spring T T′ and pallet d during the return vibration, and in detent E E′ during the impulse vibrations, and is therefore measured by the product of the elastic force of these springs and the radius of discharging contact; hence, to make this resistance of the smallest account against the balance-momentum, we have to make spring resistance and radius of pallet contact at a minimum. There is no limit to the weakening of T T′ by reason of the mechanism, so long as it is not injured;

but as regards $k' k''$ it is different, because it has to bear the rotary force of the escape-wheel in its repose. During this repose the rotary position of the escape-wheel requires to be so adjusted that the impulse-roller, although its circumference dips within the periphery of the escape-wheel, clears both adjacent teeth of the escape-wheel, in order that the balance makes no contact. This position of the escape-wheel is determined by the face of the detent-pallet F, which has therefore to be at an angular measure of a tooth and a half, or 36°, or else two teeth and a half, or 60°,—the former being adopted in English escapements and the latter in French, which is mostly the pivoted detent, yet to be explained.

The face of the pallet F forms about an angle of 95° with the direction of the wheel, or, in other words, an angle of 5° with the wheel-radius to point of contact, by which we get the conditions of an inclined plane; and the force of the wheel induces a very slight tendency to draw the pallet to its centre, and so holds it to the stop-screw, *n*, during its repose, as is the case with escape-wheel, locking-planes, and banking-pin in the lever escapement. It is by reason of this locking that we require the detent section $k' k''$ to be of maximum strength consistent with minimum balance resistance, because, if too weak, the contact being made under impact, or with a blow, the spring will bend; if outwards, the angle of pallet F is changed, and instead of being attracted is momentarily repelled, the result of which is, the escape-wheel is unduly released, and comes in contact with the circumference of roller B B, and thereby either produces irregularities, or causes the watch to stop. This error, called tripping, is also produced if there is much space between the detent and the wheel. The distance of the contact of wheel and pallet from that of detent and stop-screw being great, and the effect of the impact of wheel and detent-pallet contact being greater than the rotary force during repose, draws the pallet nearer to the wheel than can be sustained, whereby the spring is twisted, which in the act of re-establishing the equilibrium reacts in the opposite direction, and so throws the pallet beyond the periphery of the wheel. It may also occasionally happen if the discharging-spring is left too strong, because, when released by pallet *d* on its return motion, it returns to the detent section *y* with a blow, and if strong will throw the latter outward. By reason of this blow it may here be mentioned that no sharp edge must be left on *y*, otherwise it will cause the destruction of spring T T′.

The impulse-angle of the roller B B varies from 30° to 40°; that is, the angle moved through by the impulse-pallet *h* in contact with one tooth is generally designed at some angle within those limits. The angular measurement of the clearance between the roller and two respective teeth of the escape-wheel is an average of one degree each side; therefore, as in a wheel of fifteen teeth the angular measurement of two teeth is 24°, we have an impulse contact of 22°; and therefore the ratio of wheel and roller radii is inversely as the sines of half these angles—or, in plain figures, for roller impulse-angle of 40°, with an escape-wheel of one inch, that of the roller would be ·55.

The ratio of detent and discharging radius would require a more complicated formula, because of the variable centre of motion, hence we will only mention the principal conditions. We have stated the reason why the detent must return to the stop-screw before the impulse-contact ceases. As with a definite detent arc, a small roller would require a larger corresponding angular movement of the balance than a larger roller, and as the balance-arc of discharging contact is controlled by the impulse-arc, it follows that the smaller the discharging-roller the more delicate is the contact, and the more unsafe. But, on the other hand, by a larger roller we increase the roller factor of resistance; therefore in determining these ratios these are the points of limitation.

In Swiss chronometers the detent is mostly mounted on pivots, like the pallet-staff in the lever escapement, and is then kept in its position against the stop-screw by a spiral spring fixed to its staff. Here we have more constant conditions, and may define the ratio of detent and roller radii as 1 to ·084.

If the reader will consider these points, he will readily perceive that it is a very delicate escapement, requiring great skill in making, careful wear, and practised hands for keeping it in order, and hence costly to manufacture and to maintain. There is, however, one great drawback to it for general use, arising out of the very principle which gives it the advantage at its minimum perturbation of balance momentum—viz., its only receiving impulse every second vibration; hence a chronometer and a rough-wearing proprietor are often a plague to a watchmaker for this cause; therefore, a chronometer is an escapement for a scientific and not for a popular watch, and any attempt to overcome this difficulty deprives it of an element of its merits.

A very complicated modification of the chronometer escapement to remedy this evil, and to make it more fit for a popular watch, was invented by an American, and patented and manufactured in this country, and called the "double-impulse chronometer escapement." But while it deprived the chronometer proper of its simplicity and advantage, it added delicacy and difficulty of construction, and hence, by its cost of manufacture, expense of maintaining, and limited result for time, defeated its own plan, and so left the chronometer master of the field.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XIX.—SCHOOL MUSEUMS (*continued*).

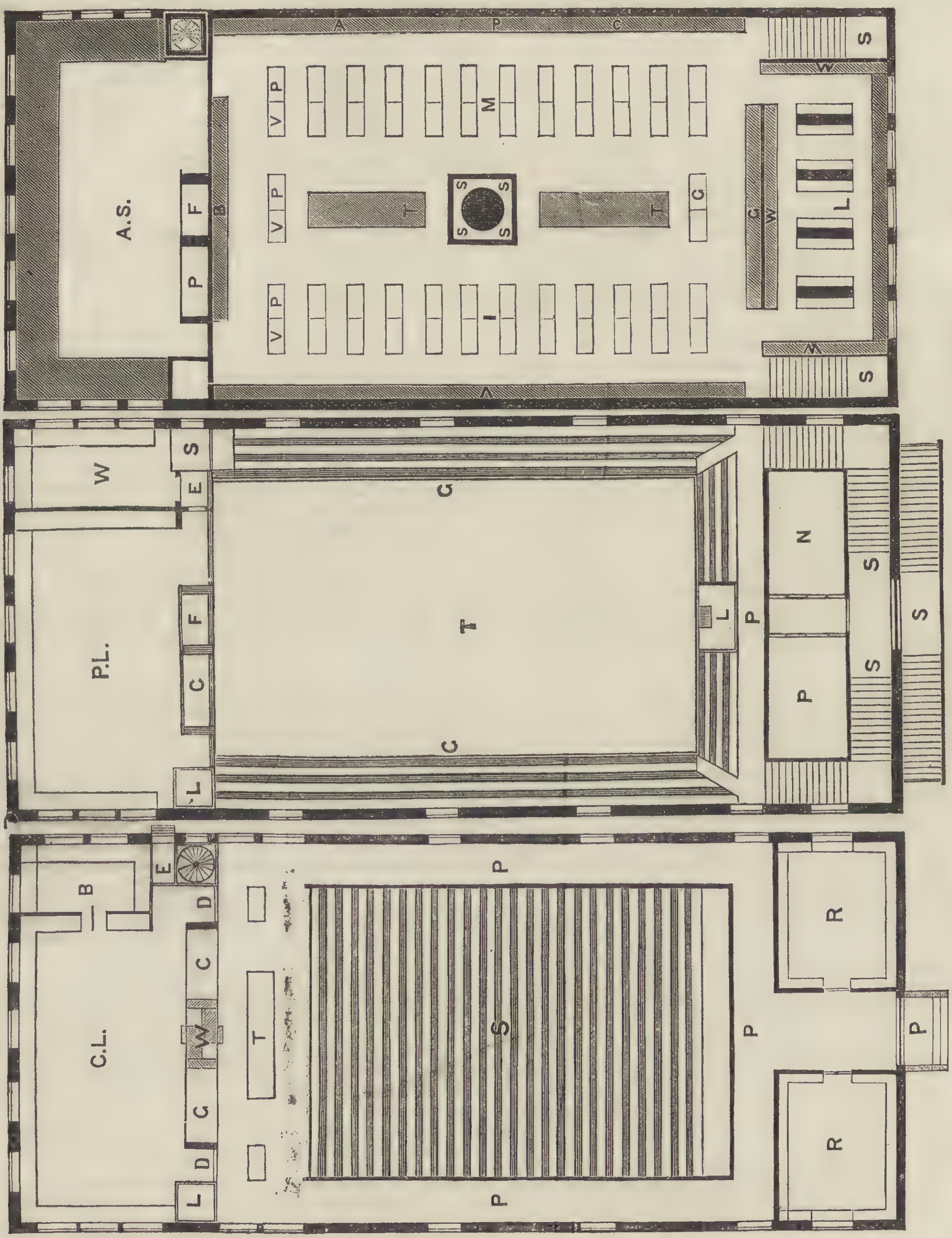
CONSTRUCTIVE DETAILS OF A SCHOOL MUSEUM.

As I have already stated in a former paper on this subject, I consider that any serious attempt at science-teaching in our great schools would require a large *lecture-theatre* (the exact size being suited to the average muster-roll); a *museum*, wherein can be permanently and openly displayed all materials employed in giving instruction, so that the same may be always accessible to studious boys at seasonable hours; *Chemical*, *Physical*, and *Natural History laboratories*, for the practical pursuit of science; and, if possible, an *astronomical observatory*. If space permitted, I should give an Arts school a place in the same building, in immediate contiguity with the museum, so that advanced students in drawing and modelling might avail themselves of the skeletons and external forms of animals, etc., therein contained. "The Science School," as such a building might be generally termed, should be designed for work, not show, and not a foot of ground should be wasted. In conveying a notion of what I consider a suitable arrangement to meet the above requirements, I shall describe a *typical* structure, one which may be modified by lengthening or shortening, widening or narrowing, to suit the average muster-roll of any school, or a given site; further, that it will admit of being built in sections, according as to what may, under different circumstances, be regarded as of primary importance and attainable. In one case a lecture-theatre and museum; in another the scientific laboratories; in another a library and reading-room, with a theatre and museum looming in the distance when funds were secured; in another a typical and local museum only. I have assumed as a basis for calculation an average muster-roll of about 500 boys, so that the body of the lecture-theatre should hold the entire school for special lectures and addresses, with gallery space for some 360 persons extra on the occasion of the presentation of prizes and the occasional gatherings of pupils, friends, and patrons.

The ground-plan of this "Typical Science School" is shown in Fig. 29, and represents an oblong building 105 feet long by 48 feet wide. P is a porch that gives entrance to a passage 10 feet wide, on either side of which are doors leading into rooms, R R, 17 feet by 15 feet and 13 feet high, which serve the double purpose of officers' private rooms and libraries, the walls being fitted, with the exception of door and window spaces, with bookcases from floor to ceiling, and the space beneath the tables with map and diagram trays. The 10-foot entrance passage leads to a theatre 64 feet long by 45 feet wide; a 5-foot passage borders the body of the theatre, which is occupied with a block of seats, S, 35 feet wide by 46 feet 8 inches from front to back, rising one above another, on an incline rising 13 feet in 46 feet, giving accommodation to 500 boys, an average space of 17 inches in width by 22 inches in depth being given to each. Every row would thus accommodate twenty-five boys, and every 100 boys would occupy a depth of 7 feet 4 inches. Each row of seats is approached by side-passages up the incline, which can be covered by hinged seats, when the rows are filled up. The filling of the seats would involve a certain amount of drill; each class (that containing the youngest boys first) would have to

march "in fours" as far as the entrance into the theatre, then divide right and left "in twos," each column wheeling to the foot of the incline, and then filling the seats to the middle line. Facing this block of seats is the lecture-table, T, 15 feet long by 3 feet wide and 3 feet high.

Fig. 35. Fig. 33. Fig. 29.



PLAN FOR A SCHOOL LECTURE THEATRE AND MUSEUM OF TWO STOREYS.

Fig. 29 showing ground floor; Fig. 33 showing gallery floor; and Fig. 35 showing upper floor or museum storey. A longitudinal sectional view of a building thus constructed is shown in Fig. 37.

The lecture-table requires careful consideration as to the best construction, for on its provision to meet every requirement of the lecturer his comfort depends. There should be ample space for the proper arrangement of experiments and specimens; a table 15 feet long, by 3 feet wide and 3 feet high, is a convenient size. The top should be at least $1\frac{1}{2}$ inches thick, clamped at each end to prevent warping; the centre hollowed out to admit the body of the lecturer; and the part immediately in front of him covered with stout sheet lead, on which corrosive bodies, etc., can be placed with impunity. The top should be screwed down to two blocks of cupboards, each block being 5 feet long by $2\frac{1}{2}$ feet in depth; the side next the lecturer being fitted with two doors $2\frac{1}{2}$ feet wide, and the front with a panel that can be used as a black board; the frame-work like the rest of the table being oak grained, the centre between the

two blocks being closed in front with a third panel. One cupboard should be divided horizontally by a large shelf, and the sides fitted with shelves 6 inches wide, for the reception of large and small apparatus immediately connected with the lecture-table, such as gas-furnaces, sand and water baths, retort-stands, supports, etc. The block on the lecturer's right hand should have one-half fitted with deep drawers for the reception of corks, bungs, tow, filtering paper, red vulcanised tubing, cloths, etc.; the other half with a large pneumatic trough of the pattern shown in section in Fig. 30. This must be placed on a shelf immediately under an opening of corresponding size cut in the table-top, fitted with a removable trap. If the trough is not placed to the right hand of the lecturer, it is not in the best position for showing the transfer of gases, etc., as the manipulation would be back-handed, and the *modus operandi* not so well seen by the students. The central space should be fitted with a drawer 4 inches deep, divided for the reception of stopcocks, connectors, binding-screws, cork-borers, triangular and rat-tail files, cork knives and rasps, crucible tongs, test-tubes, holders, folded filter papers, test papers, diagram chalks, and all such appliances as may be required at a moment's notice during chemical or physical lectures, the rule being that "there should be a place for everything, and everything in its place." A full description of such appliances will be found in that valuable modern laboratory hand-book, Greville Williams' "Chemical Manipulations." Beneath this drawer a pair of double bellows should be fixed, with the treadle ready to the foot of the lecturer; this should be fitted with a "two-way cock," and a metal tube passing therefrom to a screw-fitting let into the centre of the table-top, the second way being fitted when required with flexible tubing. Such bellows may be used for gas blast-furnaces, blowpipes, and the siren used in experiments on sound. Fig. 31 shows a telescopic universal-jointed blowpipe of simple construction that can be connected with the double bellows; and Fig. 32 a gas and air crucible furnace not hitherto described, which admits of a small crucible and its contents being brought to a white heat with that rapidity which is so advantageous for lecture demonstrations. The mixed gas and air jets point upwards and downwards on the crucible, and the whole is surrounded with a sheet-iron crucible jacket. The lecture-table must be fitted with two large binding-screws, connected by insulated copper wire with the battery cupboard.

On each side museum

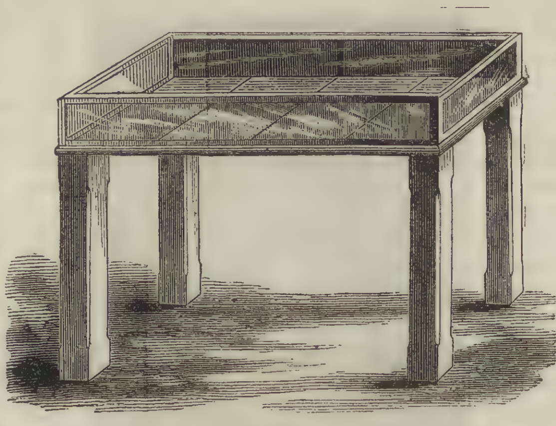


Fig. 36.—CHEAP SCHOOL MUSEUM TABLE-CASE.

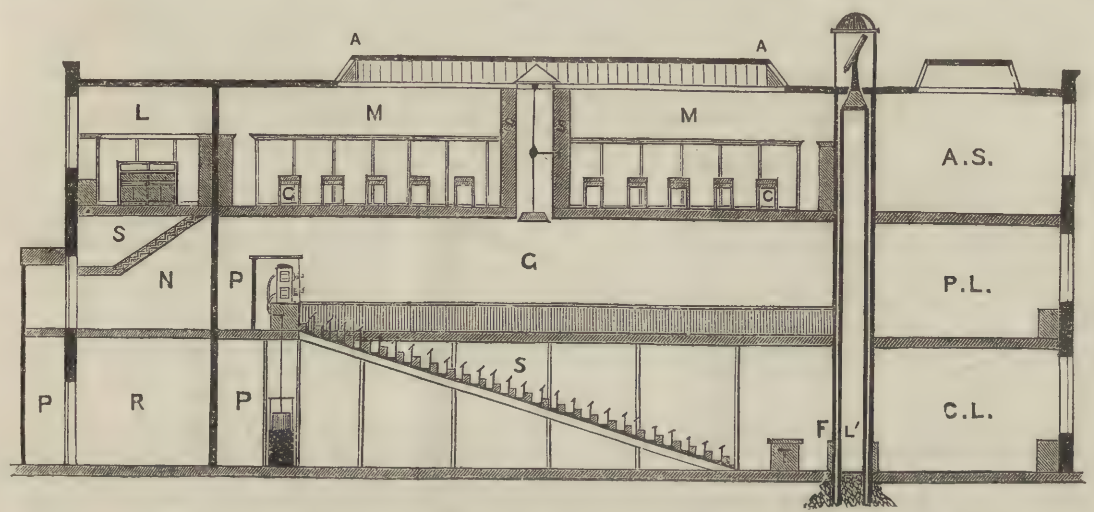


Fig. 37.—LONGITUDINAL SECTIONAL VIEW OF SCHOOL, LECTURE-THEATRE, AND MUSEUM. GROUND-PLAN OF STOREYS SHOWN IN FIGS. 29, 33, 35.

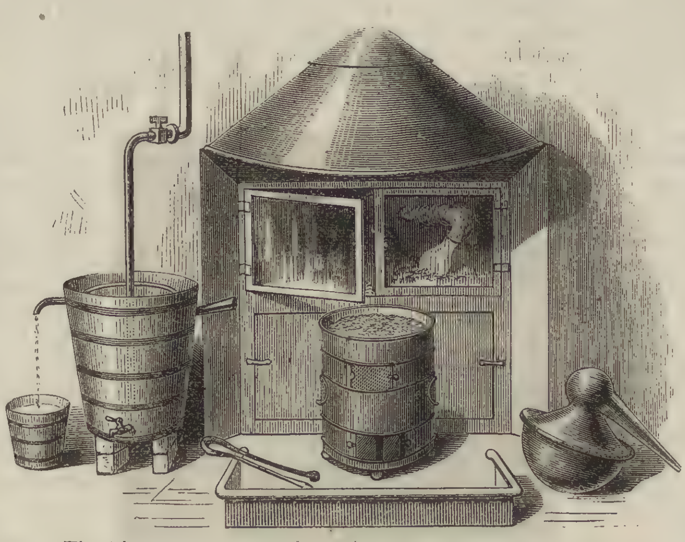


Fig. 34.—LABORATORY FURNACE SUITABLE FOR USE IN AN ORDINARY FIRE-PLACE.

table-cases are indicated. Behind the lecture-table is a projecting furnace, surmounted by a small sand-bath, the flue of which passes under and heats a long sand-bath inserted in the thickness of the wall that separates the theatre from the chemical laboratory C L, the aperture for gaining access to it being closed on both sides by glazed sliding window-sashes, W, which allow of apparatus, etc., being passed to and fro between the two rooms, and chemical operations being seen in action without obnoxious fumes passing into the theatre. To the left hand is a similar glazed recess, G, for the reception of a large series of Grove's or Bunsen's cells when the electric light is required. On the right a sashed "stink-cupboard," C, is fitted with a flat slate slab. Both the battery-cupboard and the stink-cupboard communicate with the flues of the furnaces, that all fumes generated may be carried off by the up-draught. A pair of stout insulated copper wires pass from the battery cupboard beneath the floor to binding-screws attached to the front of the lecture-table, and another pair to the physical laboratory above. On either side of this range of ventilated cupboards are doors, D D, 4 feet wide, and passages of communication between the theatre and laboratory. These doors are best covered with baize, to admit of diagrams being fastened to them. In the left-hand corner is a lift, L, 5 feet square, that passes from top to bottom of the building, to allow of instruments, specimens, and table-cases from the museum, experimental arrangements of apparatus from the physical laboratory, or models, casts, etc., from the Arts school, being sent to and from the lecture-theatre. In the right-hand corner a spiral iron staircase affords communication between the several laboratories. The laboratory, C L, measures 45 feet long by 20 feet wide, a portion, B, being partitioned off for the protection of the chemical balances, air-pump, etc. To prevent confusion, breakage, etc., students should enter this room on the left and leave by the right hand door.

Fig. 32.
GAS AND AIR CRUCIBLE FURNACE.

Students' work-tables fitted with drawers, cupboards, shelves, and sink, and supplied with gas and water, are fitted round three sides in front of the windows, the centre of the room being occupied with large tables for general purposes. The furnace is similar to that in the theatre, the small sand-bath being replaceable with a still-head, and round doors inserted in the sides for the insertion of tubes across the body of the fire. As usual, it is made of iron lined with fire-brick, both furnace and ashpit being fitted with *sliding* doors, as such admit of being fitted close round retort-necks, etc., and give perfect control over the draught-way. The flue should pass *through* the lower part of the sand-bath on its passage to the brick chimney. As before stated, both sand-bath and stink-cupboard are common to laboratory and lecture-theatre. The space beneath the sand-bath should be closed in for hot chambers; that beneath the slate slab of the stink-cupboard serves as a receptacle for coke. All special chemical apparatus, when not in use, should be kept arranged in position in the museum.

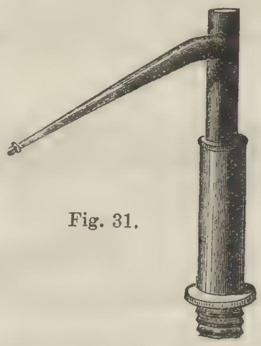


Fig. 31.

TELESCOPIC UNIVERSAL JOINTED BLOWPIPE.

The first or gallery floor, shown in Fig. 33, is approached by an external double flight of steps, S, covered by a corrugated zinc roof only, unless, through being in a very exposed position, it is deemed desirable to cover in the sides as well. To the right and left, staircases, S S, 5 feet wide, ascend to the museum floor. An entrance passage closed by doors, leads to the passage, P, of the gallery, G G, of the theatre, T, which, as previously stated, is only intended for use on special occasions. The entrance passage is formed by folding doors, which are so arranged as to allow of the two rooms, P, N, devoted to practical natural history being thrown into one on the nights of meeting of the School Scientific Society, of which this department should be the head-quarters, the entire space thus occupied being 45 feet long by 10 feet wide and 12 feet high. These rooms would be partially lighted by direct light from windows at each end, and borrowed light from the theatre and stair-passages. The section P should be devoted to the dirty work of natural history, such as the dissection of animals and plants, microscopical injections, preparations, sections, lapidary work, mounting, skeleton making (maceration being carried out in the cellar or outhouse), herbaria mounting, etc. The end window should be fitted with a large fresh-water aquarium, the sides of the room with table-shelves, at which the students could conveniently sit, supported here and there by single blocks of drawers, fitted on the plan shown at Fig. 12, page 45, Vol. IV. of THE TECHNICAL EDUCATOR, with a single row of drawers between to hold each student's tools, microscope, and working appliances. Above the table-shelf should be a narrow shelf to hold each student's jar-aquaria containing results of microscopical collections, entomological breeding-cages, cages for birds, animals, etc., under special observation. This room should be fitted with a good-sized aviary, separable into three sections; a dust-shaft, sink, water, Bunsen's gas-burners, small sand and water baths to be heated with gas when wanted.

The section N should be used as a reading-room or quiet study. The end window should be fitted with a large marine aquarium, the centre of the room with a strong table and forms. Across the room should be placed a reptile vivarium, separable into three compartments, fitted up with dwarf conifers; and an undergrowth of moss and sturdy ferns, to contain snakes, frogs, toads, lizards, newts, and other living illustrations of British reptiles. Such a work-room and study devoted to practical natural history would afford admirable practice for the systematical observation of the habits, etc., of living things, and the normal structure of dead. In this room the variations of the barometer, thermometer, rainfall, and wind should be systematically recorded under the inspection of the lecturer on natural history. By proper management of vivaria and aquaria, marine and fresh water (by no means a difficult matter, as many people fancy), a great number of living types of animal and vegetable forms may be placed before the eyes of the students. Passing on to the lecture-theatre, T, three sides are occupied with galleries, G G, the sides being 6 feet, the centre 10 feet wide, 4 feet of the latter being devoted to passage space, P. Each gallery is fitted with three rows of flap seats, similar in construction to those employed in the amphitheatre at the Royal Albert Hall, to allow of free passage between the natural history and other laboratories by the right-hand gallery through a door on the spiral staircase S. The front of the central gallery is occupied with a compartment 10 feet long by 6 feet

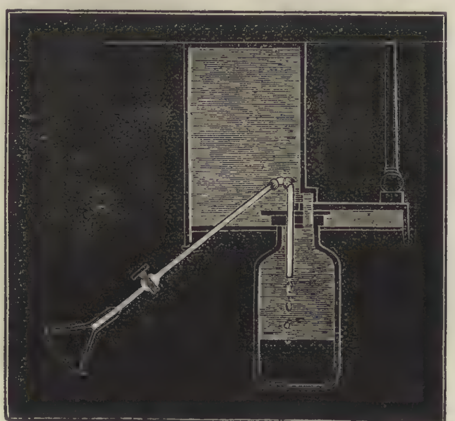


Fig. 30.—PNEUMATIC TROUGH.

wide, devoted to a dioramic oxy-hydrogen lantern, the gases being supplied from gasometers placed in a room formed by the inclined plane on which the seats in the body of the theatre are built up. The theatre is lighted by a sun-burner let into the ceiling, under a shaft passing through the roof to secure ventilation. The theatre can be instantly darkened, when lantern views are to be shown, by means of an iron shutter supported by friction rollers on two rods let into the ceiling, and which can be pulled beneath the burner or away from it by pulley and counterpoise action, worked from the lantern gallery. By the door S the physical laboratory, P L, is reached. This, like the floor beneath, measures 45 feet long by 20 wide, a portion being partitioned off for a workshop, W, fitted with carpenter's bench, lathes, circular saws, etc.; the sides are fitted with plain shelves, with a row of drawers beneath for each student's appliances. The windows in this room must be fitted with dark blinds, so that perfect darkness may be attained when needed for spectrum experiments, etc.; and one window should be fitted with a solar reflector and heliostat. Two telegraph poles should be fitted at each end of the room, to allow of wires, insulators, etc., being fixed thereon, repaired, etc., and electric telegraphs of various kinds worked by different codes. A water-tank should also be provided, for practice in (model) fuse making, torpedo firing, etc.

Besides manipulative and mathematical practice in the use of the most important physical instruments and operations, the workshop would provide means for model-making in connection with such important subjects as practical mechanics, building construction, and others. This laboratory should also be fitted with a furnace at F, but may be of a cheaper and simpler character than the one in the chemical laboratory, as it would chiefly be used for the heating or fusion of metals, etc., corrosive fumes being inadmissible where physical instruments are employed. As this form of furnace is also well suited for adaptation to an ordinary fire-place, where provision cannot be made for a special chemical laboratory, I show it in Fig. 34. It consists of a circular core or ring of fire-bricks, cased with stout sheet iron, filled with sliding doors, tube-holes, handles, and circular sand-bath, as shown in detail; above this a sheet iron hood is fixed, the wall behind the apex being pierced with a three-inch hole to carry off all fumes by the up-draught in the chimney created by the furnace fire. The aperture of the fire-place may be filled up with a sheet-iron case, the lower part being used as a warm chamber, the upper part, with glazed doors, as a stink-cupboard. The sand-bath may be replaced with a still-head. The recess C (Fig. 33) may be fitted up for the reception of apparatus in constant use, but all other physical instruments should be kept displayed in position in the museum, so that their several parts may be inspected with facility by students, when they are not in use for lectures or class work.

The museum or second floor is shown in Fig. 35. Besides a space corresponding with the theatre beneath, viz., 64 feet long by 45 feet wide, devoted to the "Typical Collections," that corresponding to the natural history laboratory and passage beneath, viz., 35 feet long by 15 feet wide, is devoted to the "Local Collection," L, the centre being occupied by the ventilating and gas-burner shaft, S. The sides are occupied by wall-cases, 7 feet high by 2 feet deep—the right-hand cases, C P A, being devoted to chemical and physical instruments, and illustrations of applied science; the central end-case, B, to botanical illustrations and vegetable types; the left-hand case, V, to vertebrate types; the lower end-case, G, to stratagraphical, geology, etc. The floor of the museum is occupied with table-cases of a standard size, 4 feet long by 2 feet wide and 3 feet high, arranged in pairs, end to end—the series on the right hand M, being devoted to the illustration of the principles of mineralogy, systematic mineralogy, rock specimens, metallurgical and economic mineralogy; the upper end-case, B, to vegetable morphology, physiology, and economic botany; the left-hand series, I, to animal morphology, physiology, invertebrate type forms, and economic zoology; the two central end-cases, G, to small characteristic fossils; tables and forms being placed at T T for the convenience of students. A *cheap school-museum table-case* is shown in Fig. 36. It consists of a bottom made of well-seasoned wood, screwed and glued to a frame fitted on three sides and the top with glass-plates puttied in air-tight; the back being closed by two hinged flaps fitting air-tight on stout felt cushions, to allow of the specimens in their trays being pushed in, four of which cover the bottom, such trays being divided with black-pinned fillets, according to the system described at page 46, and shown in Fig. 16, Vol. IV. of THE TECHNICAL EDUCATOR. This case is supported on four square legs, fitted with countersunk porcelain castors, to allow of its being moved smoothly from its proper place in the museum to the lift, by which it is conveyed to a position beside the lecture-table. The size recommended, viz., 4 feet by 2 feet, and 3 feet high, is very convenient, with the view of taking the specimens as they are arranged from the museum straight to the lecture-theatre without their being in any way unnecessarily disturbed. The space beneath can be conveniently occupied with blocks of store-drawers, constructed and arranged on the plan previously shown in these papers.

The room containing the local collection would be fitted on three sides with wall-cases, as shown at W, the fourth side being occupied with windows. The floor would be occupied with table-cases of similar arrangement to that shown at Fig. 11, page 45, Vol. IV. of THE TECHNICAL EDUCATOR, measuring 6 feet long by 4 feet wide, 3 feet high at the lower part, and 5 feet high in the centre; the space beneath being fitted with drawers on the plan shown at Fig. 12, page 45, Vol. IV. The wall-cases should contain specimens illustrative of local botany, fishes, reptiles, birds, mammals, geology and archæology; the table-cases of mineralogy, petrology, small fossils, botany, invertebrata, birds' nests, eggs, and the smaller archæological specimens. The space in front of the windows should be fitted with a table, on which specimens from drawers could be examined and microscopes placed ready for use. The windows might be made ornamental by border frames filled with magic-lantern views of local ruins, or other subjects of archæological interest. The height of the museum is 12 feet to cornice, the larger section being lighted from above by side-lights in the angle of a raised roof, similar to those found so efficient at the College of Surgeons, as previously described. The space above the wall-cases should be occupied with diagrams, wall pictures illustrating natural phenomena, etc.; in the local museum with geological sections and the maps of the Government survey of the district, etc. The museum communicates with the Arts School by the door D. This department should be fitted on three sides by windows, and with a top-light. Both walls and windows should be covered by movable curtains, of a dark mulberry colour, running on rods, to admit of proper adjustments of light and shade. Models of the best examples of statuary, vases, and bas-reliefs should be ranged around the room on pedestals, etc. Each student should be provided with a separate stool, to allow of studies, etc., being made from different aspects, or so that the entire class could be grouped in the best position around any subject, while the Arts master demonstrated special points for study. The compartment marked P should be fitted up for the practice of photography, while F will contain an ordinary fire-place. Access to the astronomical observatory would be obtained by the steps from this room.

A longitudinal section through this science school building is shown in Fig. 37. The ground floor shows the disposition of the porch, P; the library and officers' rooms, R; the five-foot entrance passage into the theatre, P; the inclined range of seats, S, which should be supported by iron struts, similar to those employed at the Great Exhibition of 1851; the lecture-table, T; the furnace, F; the block L′ containing the lift-tower, placed between the theatre and the chemical laboratory, C L. The lift-tower, built within an outer tower, to meet the requirements specified for an astronomical observatory, is shown in section. The first floor shows the landing and stairs, S, leading to the museum, the practical natural history laboratory, N; the four-foot passage, P, leading to the galleries of theatre, G; the lantern room; and the physical laboratory, P L. The second floor shows the local collection, L, the typical museum, M, the ventilating shaft, S S, which consists of a central cylinder passing through the roof, crowned by a cowl, fitted just above the museum floor with a close-fitting door to give access to the gas-burner, for lighting, cleaning, repairs, etc. This cylinder is cased with a square wood guard, the exterior of which may be utilised by being covered with large diagrams, one side being fitted with a door. A A represents the angle lights above the ceiling; A S shows the "arts school," with its top-light.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. GALLETLY, Curator, Industrial Museum, Edinburgh.

VI.—MANUFACTURE OF WOOLLEN CLOTH (*continued*).

Boiling.—This process, called "roller boiling," was introduced about fifty years ago. Although a simple operation, it nevertheless effected a wonderful improvement on the finish previously given to fine cloth, as it produces a permanent lustre on its surface which is not spotted by rain. The cloth is wound tightly round a roller, which is then made to rotate slowly in a tank of hot water for several hours. Afterwards it is placed in a cool atmosphere, or immersed in cold water for a longer period, and this treatment is repeated several times. There is a way of shortening the process by winding the cloth round a perforated metal cylinder, and allowing steam to pass through it. Among Continental manufacturers there are other plans in use, chiefly by means of pressure and steam, for giving a lustrous finish to woollen fabrics.

Pressing is the only other process we need specially notice. The first pressing is given to the cloth before the roller-boiling after it has been brushed by revolving brushes. For this purpose the cloth is folded up in regular lengths, with glazed paper between the folds to prevent the surfaces of the cloth from coming into contact. Hot iron plates are then introduced between each folded pile of fifty yards, and when a sufficient thickness or height is made up the whole is subjected to the action of a powerful screw, or, more usually, a hydraulic press. For superfine cloth the plates are but slightly heated, and the second pressing is given with the plates cold. Some inferior cloths receive a surface lustre from strong compression with highly heated plates, without being boiled or steamed at all, but when so treated they are easily disfigured by rain.

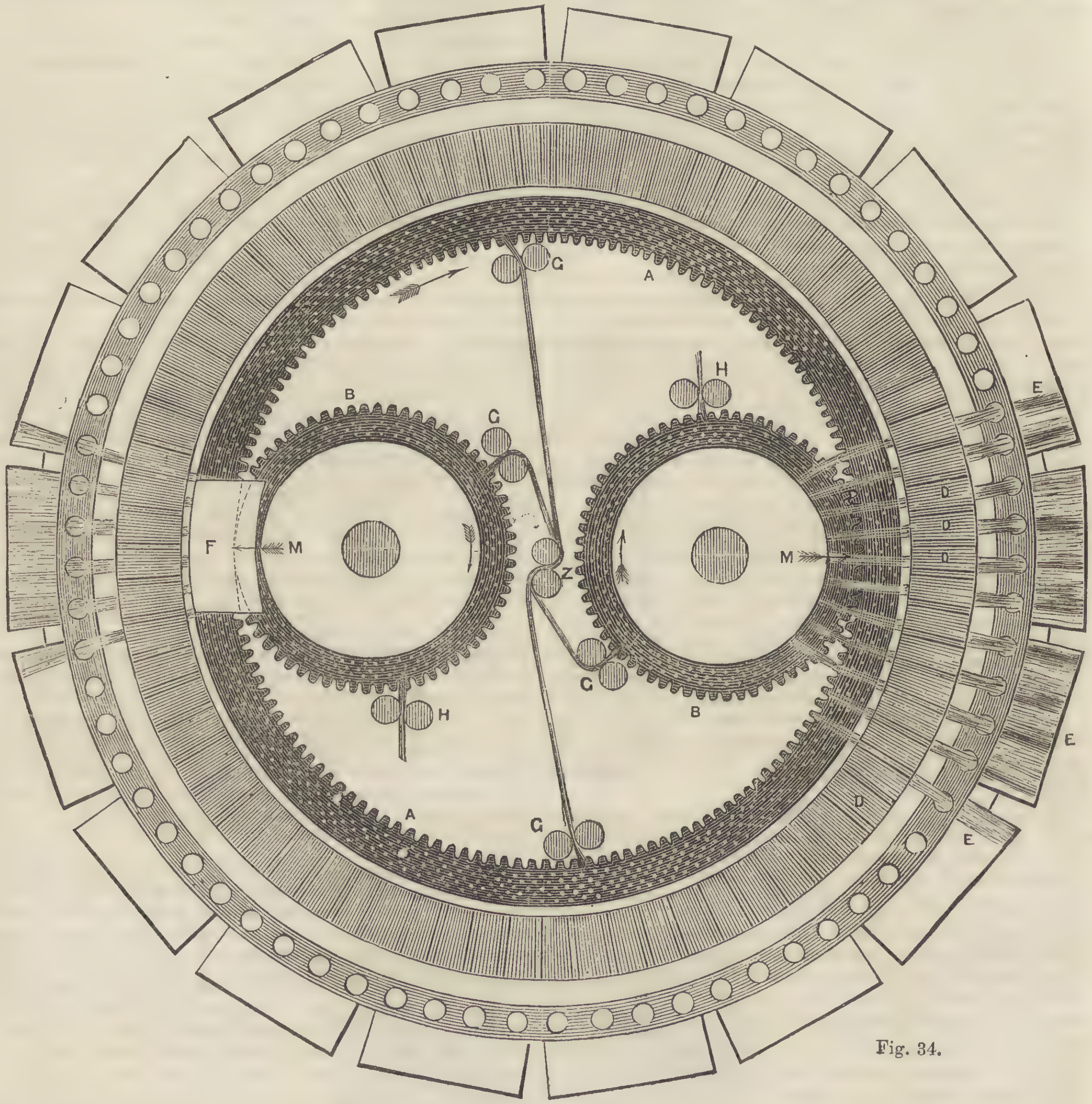


Fig. 34.

MANUFACTURE OF WORSTED CLOTH.

Having concluded our description of the more important of the multifarious processes in the manufacture of woollen cloth, we will now give an outline of the operations in a sister industry—namely, the worsted manufacture—the extraordinary development of which is one of the wonders of our time, and in which, so far as cheapness, variety, and extent of production is concerned, England surpasses any other country in the world.

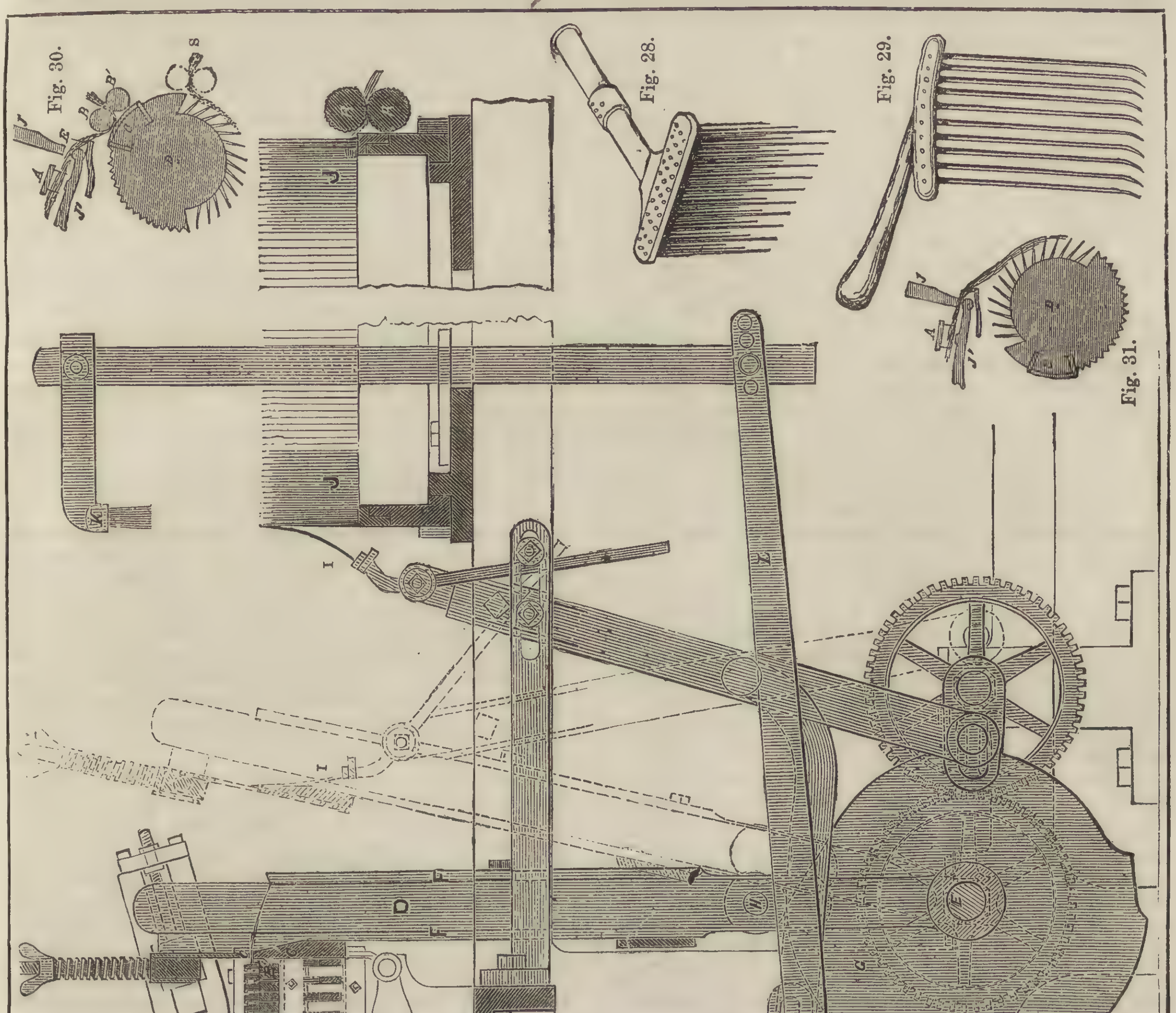


Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

Fig. 32.

Fig. 33.

The various processes in the manufacture of ordinary worsted fabric are, as already stated, fewer, and more reduced to mechanical precision than those practised for woollen cloth. They are usually as follows :—1. Sorting the wool. 2. Washing. 3. Drying. 4. Plucking, when the nature of the wool requires it. 5. Preparing by gill-boxes. 5*a*. Carding, when short wool is used. 6. Combing by hand or machine. 7. Passing combed sliver through finishing gill-boxes. 8. Drawing, say five or six times. 9. Spinning chiefly on throstle-frame. 10. Reeling. 11. Warping. 12. Weaving. 13. Dyeing.

Sorting and *washing* is performed much in the same way as already described for "woollen" goods, but "the long wool for this branch is rarely dried out so completely, so that a tendency to curl is not imparted to the fibres." When dried it is transferred to a machine called a *plucker*, where it is cleaned by a fanning apparatus, and after which, according to the old system, changed as it were but yesterday, it was ready for the process of hand-combing.

Hand-combing is—perhaps we should say was—done in this way :—Using a pair of combs, with two or three rows of teeth, like the one shown in Fig. 28, each row being of different lengths, the wool-comber fastens one when heated to a post, and then throws or "lashes" a handful of wool, previously sprinkled with oil, over the points of the teeth. He then draws it repeatedly through the comb, leaving at each pull a few straight filaments in the teeth. When the whole handful is thus taken up by the comb it is heated in the stove, and another comb, already heated, is in turn placed on the post and filled with wool in the same way. Both combs being now filled and heated, the workman, sitting on a stool, holds one in his left hand over his knee, and then with his right hand draws the points of the other comb through the wool. This operation is repeated—the workman frequently changing hands—till the wool is sufficiently combed. It is then nearly all transferred to one of the combs, heated again, and drawn off in a sliver which receives a second combing at a lower temperature. Care must be taken not to allow the combs to come into contact, although they are worked with their teeth as closely together as possible in order to straighten all the fibres of the tuft or tress. In Fig. 29 we give a sketch of a rude wool-comb used, up to the middle of last century, in the Shetland Isles: the handle is entirely of horn.

Machine-combing.—There are two classes of machines in use for wool-combing, one suitable for long-stapled, and the other for short-stapled wool. In the case of long-wool combing it is necessary, in the first place, to straighten or stretch the fibres, and also to separate or open them. This is done upon a series of "preparing gill-boxes" (a gill is a kind of comb with steel teeth), so arranged that each succeeding gill through which the wool passes has finer teeth than the one before it. When the wool is thus prepared it is ready for combing, the object of which is to place all the fibres in a longitudinal direction, and to separate the short portions of the wool, technically called *noils*, which are not suitable for spinning into worsted yarn.

All attempts to comb wool by machinery previous to 1846 were imitations of hand-combing, and, like it, produced a large proportion of short wool or noil, and were more or less wanting in continuity. M. Josué Heilman, of Alsace, was the first to construct a combing-machine which could detach tufts from a fleece, comb both ends of these tufts, and then piece them together so as to form one continuous sliver. Heilman's machine is a most ingenious invention, and has been of incalculable benefit not only to the worsted industry, but, for fine spinning, to the cotton manufacture as well. Its principle will be understood, with the help of Figs. 30, 31, and 32, which show its main elements, by the following description :—There is a fixed bar at A with two rows of teeth forming combs into which the wool is forced, and by which it is held during the drawing or detaching action of the roller B. This nipping-roller takes hold of the protruding end of the fleece when the plain or projecting portion C of the drum D comes round to it in the course of its revolution, and detaches a tuft of wool, drawing it at the same time through a second comb at E. The tuft is engaged between the drum D and the roller B till it is carried between the latter and its companion roller B′, the two rollers then by a peculiar arrangement moving bodily away. However, before the drawing-rollers B, B′, move up to detach the tuft, that portion of the drum D on which the combing teeth are placed is in the position shown in Fig. 31, and at this particular moment a pair of nipping-jaws, J J′, are made to close on the fleece and hold it while the drum-teeth comb the projecting portion of the wool. This done, the nipping-rollers B, B′ seize and detach it as already explained, and then move towards the position shown by the dotted line in Fig. 30, where the tail or opposite end of the tuft also receives a combing from the drum. Fig. 32 shows the arrangement of rollers and endless apron for piecing the combed tufts and forming a continuous sliver. There are several modifications of the machine which are used for peculiar kinds and lengths of fibre; thus, a grooved roller and guide-plate, or a pair of grooved rollers, are sometimes used instead of the nipping-jaws.

The "noil" separated in the combing falls down under the drum, but though unsuitable for the worsted-spinner, it is valuable to the woollen cloth-maker. Here is what a practical manufacturer says of it :—"It contains, so to speak, the very 'kernel' of the wool—the finest, though shortest fibres of the fleece—but it is often very nibby and difficult to card. Large quantities of this noil are exported to the Continent, where the woollen carding machinery is better adapted to card and open out the small nibs which it contains, than the corresponding woollen machinery in Yorkshire."

Another combing machine, now much used for combing long wool, was patented in 1850 by Lister and Donisthorpe, and a second patent for improvements upon it was taken out in 1851 by Mr. Lister alone. Lister's machine has little external resemblance to Heilman's, and yet it so closely resembles it in some essential parts that a protracted litigation between the two parties took place which ended, it is said, by Mr. Lister paying Mr. Heilman £30,000 for his patent. The great success attending the introduction of Mr. Lister's machine led him in turn into legal contests with others, who fought hard to invalidate his patent rights, and so share in the almost fabulous profits this important machine was making. The patent has now, of course, expired. Fig. 33, taken chiefly from the drawing in the specification of patent, shows Lister's machine in longitudinal section, and we shall try to explain its action without going much into detail. The partially prepared wool from the gill-boxes is fed through a pair of grooved rollers A, A′ to a series of gill-combs, B, B′, B″, which are worked by screws on the gill-shafts S, S, and carry the wool forward to the point where the gill-comb marked B″ is shown on the diagram. These gill-combs are heated by travelling over jets of gas, as when this is done not only does the wool comb with greater facility, but the heat also tends to preserve the teeth of the gills. From the face of the gill-teeth at B″ the wool is detached in tufts by the nipping-jaws C, C′, which comb the back or tail end of each tuft in the act of drawing it out of the gill. These nipping instruments are carried on a reciprocating frame D, moving freely on a shaft E, and having side-plates F, F, which move up and down by the cam G acting on the roller H, and so press the lower jaw C′ against the upper fixed jaw C as required. When the tuft is seized, the frame carrying the nippers moves forward to the position shown by the dotted lines, and a porter or carrier-comb I now approaches, and by a peculiar motion enters its teeth into the end of the tuft held by the nippers which open at the same moment. A link motion then carries the porter-comb I to the circular receiving-comb J, upon which it is deposited and pressed down by the brush K, which has an up-and-down motion given to it by the lever L. Up to this stage the wool has only been combed at one end, and now as tuft after tuft is placed on the receiving-comb, while it travels round, these are carried forward in its circuit till a pair of rollers, R R, draw them off in a continuous sliver, called the "top," their opposite ends being cleaned of noil as they are drawn from the comb. Another arrangement clears the teeth of the noil.

A Lister wool-combing machine was shown in the International Exhibition of 1871 with a circular receiving-comb, four feet in diameter, which combed fifty pounds of wool per hour. Formerly a hand-comber could not do as much in a day, while his work was much less efficiently performed.

There are some wools used in the worsted trade which are too short in the staple to be prepared on "screw gills" or combed on machines like Lister's. Such short wool requires to be carded on a carding-engine, which, however, differs materially from those used in woollen factories, since in worsted carding the object is to lay the fibres all in one direction, as well as to clean them, and at the same time preserve their length. The carding operation accordingly produces a continuous sliver, with

the fibres for the most part parallel to each other and ready for combing.

For short as well as for long-stapled wool there are several combing machines employed. One of the best in use for combing short wool is Noble's, which was shown in motion in the International Exhibition of 1871, by Mr. S. B. Walmsley, of Bradford, and of which a large number are now at work in all parts of the world where worsted manufacture is carried on. In Fig. 34 we give a kind of horizontal plan of its chief parts with the driving gear left out, the figure being only intended as a diagram. The large circular comb A is filled with several rows of teeth, represented by dots in the figure, as we are supposed to be looking down upon them, and is driven round by the outer toothed rims of the two smaller circular combs, also with rows of teeth, B, B′. These receive their motion from spur-gearing and connections, the ingenious arrangement of which regulate with great nicety all the parts of the machine. Outside of, and concentric with, the large comb there is a circle of seventy-two feeding-boxes, D, D, D, with lids, and outside this again a ring of metal with seventy-two holes. Attached to this ring, but on a lower plane, are two concentric rows of bobbins, of which only the outer one, marked E, is shown in the figure. These bobbins contain the carded slivers, and along with the feeding-boxes D, move round with the large circular comb.

The machine acts in this way. When near to the two opposite points M, M, where the large and small combs come together, and only there, the feed-boxes D, through which the slivers of wool pass freely, rise by means of a cam; and at the same time the wool is held by an iron plate, so that a sufficient length of sliver is drawn up from the bobbins and placed by the feed-boxes across the teeth of both combs. A brush, F, at the same moment presses it down into the teeth, as in Lister's machine, and then as the combs divide, a fringe or tuft is left on both combs, one being pulled by the smaller through the teeth of the larger, and the other being pulled by the larger through the teeth of the smaller. The same action of course takes place at both points M, M. After the combs divide the boxes remain down till the sliver is drawn at G, and then rise again for the next feed. A continuous sliver of combed wool, or "top," is drawn off at four different points by the rollers G, G, G, G, and wound up at Z, while the "noil," or short wool, is drawn off at H, H.

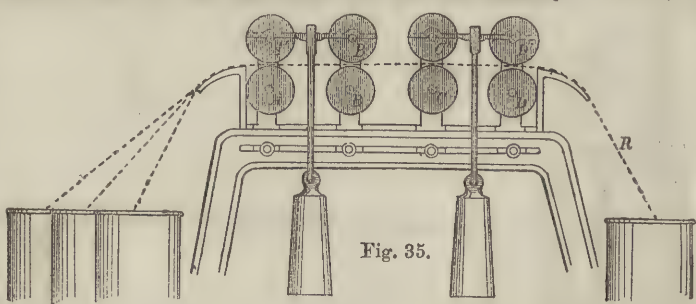


Fig. 35.

After being combed the sliver or "top" is twice passed through what are called "finishing gill-boxes." These are of a similar nature to the gills in the long wool-combing machines, and still further aid in straightening and rendering more perfectly parallel the fibres of the "top," which is now reduced in size and is ready for the "drawing" process.

As it will serve to connect the processes, we give a diagram of the elements of a drawing-frame in Fig. 35, although it is nearly the same as that used for drawing-out cotton. The difference between the two is chiefly in the distance between the rollers, and in having the means of making this greater or less in a worsted drawing-frame, so as to suit the length of the fibre. The drawing-rollers are loaded with weights in some such way as that shown in the figure, so as to prevent the sliver slipping through without being drawn out, and a suitable arrangement of toothed wheels regulates their speed. The function of the drawing-frames is to remove all inequality in the sliver or slubbing, to average and equalise it, and to reduce it by degrees to the proper size for the spinning-frame. In a drawing-frame there are several pairs of rollers so regulated that the first pair move slowly, and each succeeding pair faster than the one before them. Thus B B may move twice, C C′ four times, and D D′ six times as fast as A A′, by which arrangement the three slivers (shown in the figure by dotted lines), after being united into one, would be drawn out to six times their original length. Suppose that six instead of three slivers were drawn into one, and then extended in length six times as above, the resulting sliver E would be of the same average weight per yard as any of the original six, but with its fibres much more equally laid and less liable to tear across. This operation is generally repeated five or six times, but the precise number of drawings, as well as the extent of each, depends altogether on the fineness of yarn required. The whole extension is seldom less—usually it is very much greater—than a thousand times, which would be roundly arrived at by four drawings as follows:—1st. Six slivers drawn into one, making 6; six of these again drawn into one, making 36; six again into one, making 216; and finally five into one, making 1,080. That is to say, supposing there had been no doubling, the combed sliver would thus be drawn out 1,080 times its original length. It really is so, only several are joined together at each drawing, in order that it may be more evenly and uniformly reduced.

Roving and *spinning* succeed the drawing process, both of which are done upon frames similar to those used for the same operations in the cotton manufacture. In roving the sliver is still farther drawn out by rollers on the same principle as those in the drawing-frames, but owing to the great attenuation reached at this stage it requires to be twisted to save it from breaking. In spinning worsted the extension or draught of the roving is much greater than in cotton. The spinning is chiefly done on the throstle-frame, with spindles and flyers for long wools, and with spindles and caps for short wools. Sometimes, however, the mule is used, and, it is said, even largely in France.

Weaving.—Power-looms have been in use for worsted stuffs for about fifty years, yet in France, where the worsted manufacture is so successfully conducted, the number of hand-looms exceeded the power-looms even so recently as 1867. Some good judges think, indeed, that the superiority of the French all-wool goods is partly due to the skill of her hand-loom weavers. However, the recent rapid growth of the worsted industry in that country is known to be owing to a more extensive use of power-looms; and in England hand-weaving in this manufacture is a thing of the past. The perfection to which English power-looms have now been brought is shown by the fact that the worsted fabrics of France, Russia, Sweden, and Spain are to a great extent woven upon them. It is stated in Mr. Leach's report on the woollen and worsted machinery in the International Exhibition of 1871 that a single English maker, Mr. George Hodgson, of Bradford, turns out about 7,000 plain looms, such as are used for Orleans cloth, per annum. One of these will weave a yard in ten minutes, so that here are as many power-looms made in one establishment as will weave 70,159 miles of cloth in a year, or as much as would go nearly three times round the globe. In addition to these, this same maker constructs a large number of looms for weaving check and fancy stuffs.

THE LATHE.—XIX.

By Henry Northcott.

AMATEURS' LATHES.

Turning is such an interesting art, that it is not surprising its practice is very far from being confined only to engineering works. Indeed, from the earliest age of the lathe it has been a very favourite instrument of amusement with persons having leisure and a taste for mechanics; and amateur turning, both plain and ornamental, is now so extensively practised, that not only are lathes and apparatus specially designed for such work, but the construction of such mechanism has become almost a distinct business.

The distinctive features of lathes used by the amateur and ornamental turner are lightness, high finish, and the power of being applied to the execution of a great variety of work not usually performed in the lathe.

Some of the simple forms of lathe already described may be

termed amateur lathes; but the lathe best of all suited to the amateur mechanic is a light screw-cutting lathe of about five-inch centres, with treadle motion, and carefully designed slide-rest. Such a lathe as this, when provided with the necessary tools and apparatus, is capable of executing almost any kind of light work, and is altogether a most useful instrument.

Fig. 124 shows an amateur lathe made by Mr. Munro, of Lambeth. It has a strong treadle motion with two cranks and chain connections, four-speeded cone-pulley grooved for a gut-band, and driven from a fly-pulley with two sets of speeds, for fast and slow driving. The double gearing has an endway motion for throwing it into and out of gear, and the two head-stocks are neatly designed, and calculated to be very efficient in use. The leading-screw is outside the bed, and it is used for end is a double-speeded grooved driving-pulley. The motion is conveyed to the lathe-pulley by a gut, and as the leading-screw comes rather in the way, a small guide-pulley is affixed to the bed just under the screw, to keep the gut coming into contact and rubbing against it. The face of the large spur-wheel upon the lathe-spindle is turned flat, and is converted into a division-plate by being divided at the edge, and furnished with a spring-pointer for taking into the division-holes. A division-plate is a very useful addition to a lathe of this sort, and the mode of carrying it out is very simple. The motion for screw-cutting is taken off the lathe-spindle by a series of small pinions, two of which being placed upon a rocking-plate allow the direction of the rotation of the leading-screw to be arranged for cutting a right or left-hand screw, by merely shifting one or other of them into gear with the driving-pinion. As thus designed, the

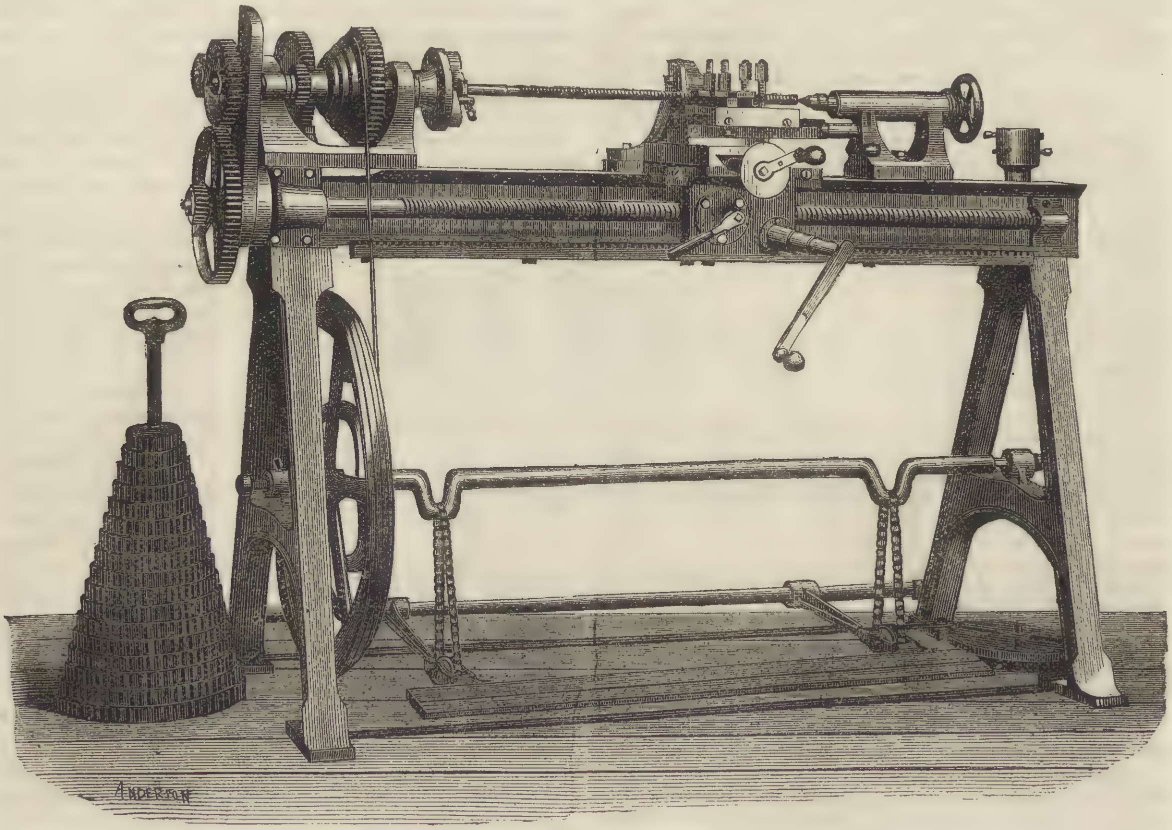


Fig. 124.—AMATEUR LATHE MADE BY MR. MUNRO, OF LAMBETH.

both sliding and screw-cutting, as for these small lathes separate sliding mechanism would be an unnecessary complication. A separate rack and pinion is, however, provided for traversing the slide-rest along the bed by hand.

Turning to the slide-rest, it will be seen the lower slide is a fixture at right angles to the bed; but the upper slide may be set at an angle for angular and taper turning, or it may be removed altogether; neither is self-acting, the motion being given upon the surface and angular cuts by turning the respective slide-handles.

The lathe is shown chasing up the thread of a slender screw; the arrangement of change-wheels for obtaining the pitch will be seen clearly from the illustration.

Figs. 125 and 126 are two views of a lathe made by Messrs. T. Cooke and Sons, of York, which embodies several features not hitherto exhibited in any of the lathes described. The bed is mounted in the usual manner upon two standards, except that it projects some distance out over the standard at the right-hand end. The treadle motion has a single crank only, which is placed at one end of the crank-shaft, and at the other socket of the lowest of the pinions takes the place of the lathe-spindle, and the wheel that would in the lathe last described be placed upon the spindle, is here placed upon this socket; the intermediate and the leading-screw wheels being arranged as usual.

It is in the slide-rest that the main departure from ordinary practice becomes observable, and the present design possesses advantages that should cause it to be more generally adopted. In the ordinary plan, the rest-saddle is placed upon the top surface of the lathe-bed, which is planed and scraped up to a true surface; but the dust and shavings from the work are continually falling upon the bed-surface, and this being slightly oiled, the small particles of iron and grit adhere, and getting between the surface of the bed and saddle, cause a good deal of friction and wear. If the lathe be in the hands of a careless person who does not continually keep the sliding surfaces free from the grit thus deposited, long scratches and ruts soon become scored upon the well-scraped bed, and also in the under surface of the saddle, although they are there out of sight. Even with a careful turner the bed is sure to become scratched

sooner or later, as it is almost impossible to keep the dirt out of these slides. Messrs. Cooke's arrangement of slides is not so liable to this kind of injury, owing to the slide upon the bed being more out of the way of falling shavings, and also owing to the less surface actually exposed to receive them. This, however, is not the main advantage possessed by the outside slide.

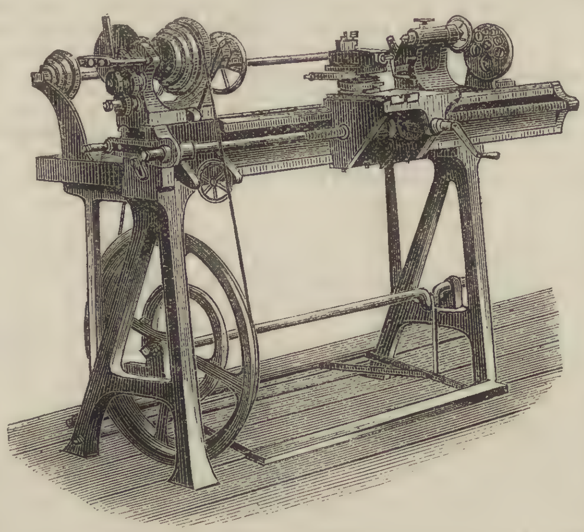


Fig. 126.—AMATEURS' LATHE, BY MESSRS. COOKE AND SONS, OF YORK.

An ordinary rest-saddle sliding upon the bed can only be moved anywhere along the bed between the two headstocks; whilst in this lathe, the saddle being hung on the outside of the bed, it may be moved along the lathe-bed past the right-hand headstock, of whose position it is quite independent. This is frequently a great convenience, as it removes the slide-rest out of the way, and shows a clear field in front of the work for the more convenient application of a hand-tool rest, and for other purposes. The mode in which the saddle is placed upon the bed will be clear from the figures. It is traversed by the leading-screw with a nut affixed to the saddle, and the hand-traverse is obtained through a handle, which by means of a pair of bevel-wheels drives round the leading screw-nut. The upper part of the saddle is fitted with a flat groove, in which is placed the foot of the compound slide-rest; this foot can be pushed in its groove either towards or from the centre-line of the lathe, so as to give any required nearness of the tool to the work, and a dovetail groove with a bolt on the under-side of the foot provides the means of fastening the whole rest down upon the saddle. There is also a rising and falling motion between the upper slides and their foot-piece, by means of which the point of the tool may be adjusted to the height of the lathe-centres. At the back of the lathe, and extending nearly the length of the bed, is a light supplementary shaft carrying some V-pulleys, as shown. The object of this is to drive certain instruments used for drilling and other purposes, which are held in the slide-rest, and which require rapid rotation to enable them to do their work.

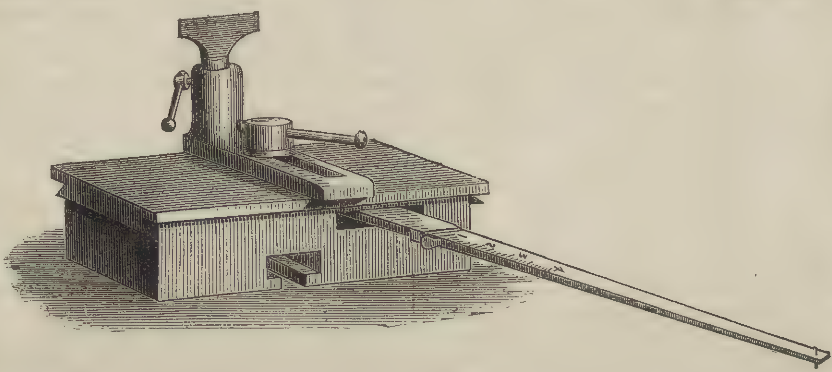


Fig. 127.—APPARATUS FOR CUTTING SCREWS IN A HAND-TOOL LATHE, BY MESSRS. T. COOKE AND SONS, OF YORK.

Altogether, this is an excellent example of a lathe for light, accurate mechanical turning, and Messrs. Cooke and Son's workmanship is well known to be excellent. Another contrivance of Messrs. Cooke's, which to the amateur turner is of great assistance, is an apparatus for cutting screws in an ordinary hand-tool lathe. This contrivance, shown at Fig. 127, was invented by Mr. Cooke in 1838, and has been in daily use at his works since that time. By the use of it an inexperienced hand is enabled to cut screws, the machine giving him a true lead, after which he may finish them by turning in the usual way, the only attention requisite being the steady holding of the screw-tool on the small rest of the instrument, and giving the necessary reciprocating motion to the lathe. In use, the machine is clamped to the lathe-bed in the same way as an ordinary hand-tool rest, and as parallel to it as the eye is capable of judging. The projecting lever extends to the opposite side of the lathe-bed, along which a cord is stretched, and which being looped on to the small pin at the end of the lever, connects it to the lower part of an upright wooden pulley, the cord being kept tight by a weight at the lower end. Another cord connects the upper part of the pulley to the lathe-mandril. Before looping the cord on to the small pin, however, there should be several turns of the other cord made round the mandril. The reciprocating motion is then given to the lathe by the treadle, care being taken not to make a complete revo-

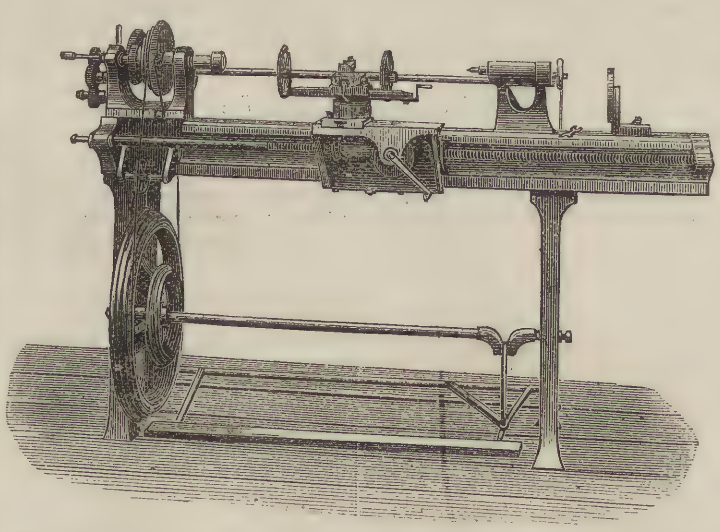


Fig. 125.—AMATEURS' LATHE, BY MESSRS. COOKE AND SONS, OF YORK.

lution of the crank. A sliding index traverses a divided portion of the lever, and when it is desired to use the apparatus, the required number of threads per inch divided into forty will give the corresponding number opposite which the sliding index should be fixed. Thus, if ten threads per inch are required, then $40 \div 10 = 4$; the index, therefore, should be fixed opposite the figure 4 of the divisions, and the corresponding screw-tool held on the rest.

In chasing screws by hand the great difficulty is to catch the pitch, and this is the object of the above contrivance. The completion of the screw, when once the spiral is caught, is a matter of no great difficulty, and a comparatively small amount of careful and steady practice will enable the amateur to accomplish this in a creditable manner and to his own satisfaction, and in far less time than he could do it without the aid of this useful apparatus.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLVII.—COLIN MACLAURIN, MATHEMATICIAN.

This eminent philosopher was a native of Tiree, an island of the Argyleshire Hebrides, twelve miles long by four in breadth, usually called by the Highlanders *Rioghacd bar fo thuin*, or the "kingdom whose summits are lower than the waves," as it is the flattest islet in that part of Scotland. Colin was the youngest son of the Rev. John Maclaurin, minister of Glenderule, and was born in the manse of Kilmodan in February, 1698. His father died six weeks after this event; but the loss to his family was not so severely felt as it might have been, owing to the kindness and benevolence of an uncle, the Rev. Daniel Maclaurin, minister of Kilfinan, in the district of Cowal, and the careful and exemplary virtues of his mother, at whose death, in 1707—the year of the Union—the charge of her orphans entirely devolved upon the uncle.

By the latter Colin was sent to the University of Glasgow, and in his fifteenth year took there the degree of M.A., on which occasion he composed and defended a thesis on "The Power of Gravity." From the time he entered the college he kept a diary, in which he carefully noted down the beginning and success of every particular study, inquiry, or investigation, his conversations with the learned, and the arguments on either side. His genius for mathematical science discovered itself so early as his twelfth year, when, having accidentally found a copy of Euclid in the room of a brother student, he became in a few days master of the first six books without any assistance. He now made an extraordinary progress, and began to engage himself in the solution of the most difficult and curious problems. The depth and boldness of the topic selected by young Maclaurin in his thesis at once revealed the nature of his studies while at the university, and excited the wonder and admiration of all who were present. At that time the philosophy of Newton was comparatively unknown, especially in Scotland; and men, even the most distinguished in science, were slow to comprehend the great and important truths his system contained. "When, therefore, young Maclaurin chose the 'Power of Gravity' as the subject of his thesis, it was a pre-supposition that he was fully acquainted with the fundamental doctrines of Newton's discoveries, and on this occasion he acquitted himself to the wonder and delight of his auditors. He afterwards illustrated the same subject in a most beautiful manner in the last two books of his account of the philosophical discoveries of Sir Isaac."

Nothing delighted Maclaurin more than to be engaged in difficult problems; and it is now certain that, before attaining his sixteenth year, he had invented many of the finest propositions, afterwards published under the title of "Geometria Organica." In 1714 he began the study of divinity; but disgusted by the dissensions which so frequently prevail in the Church of Scotland, he relinquished all idea of becoming a clergyman, and happily for science and mankind devoted himself to the study of mathematics and philosophy.

When only nineteen years old, in the autumn of 1717, he had the confidence to become a candidate for the chair of mathematics in the Marischal College of Aberdeen, and he was elected duly thereto, after a competition which lasted for ten consecutive days. In the vacations of 1717 and 1719 he went to London—a long and arduous journey in those days—with the view of extending his information; and there he became acquainted with Sir Isaac Newton, Dr. Hoadley, Dr. Samuel Clarke, Mr. Martin Folkes, and other eminent men, and was admitted a member of the Royal Society.

In 1722, Alexander, Lord Polwarth, K.T., afterwards Earl of Marchmont, then ambassador from the Court of St. James to the Congress of Cambray, selected him as a travelling tutor for his son, Mr. Hume, who was about to make what was known in those times as "the grand tour;" and while in France he wrote his essay on "The Percussion of Bodies," which gained the prize of the Royal Academy of Sciences in 1724, and the substance of which is embodied in his "Treatise of Fluxions." The sudden death of his pupil at Montpellier caused Maclaurin to return to Scotland, and resume the duties of his chair at Aberdeen. In 1725 he was chosen to succeed James Gregory as Professor of Mathematics at Edinburgh, where his lectures, which began on the 3rd of November in that year, contributed greatly to raise the character of the metropolitan university. The first to congratulate him on his appointment was Sir Isaac Newton, who afterwards wrote thus to the Lord Provost:—

"I am glad to understand that Mr. Maclaurin is in good repute among you for his skill in mathematics, for I think he deserves it very well; and to satisfy you that I do not flatter him, and also to encourage him to accept the place of assisting Mr. Gregory, in order to succeed him, I am ready, if you please to give me leave, to contribute £20 per annum towards a provision for him till Gregory's place becomes void, if I live so long, and I will pay it to his order in London."

This was, however, declined, his means proving sufficient; and in 1733 he married Anne, daughter of Walter Stewart, at that time Solicitor-General for Scotland. Maclaurin was the first who proposed the building of an astronomical observatory, and a convenient school for experiments in the University of Edinburgh; but he did not live to see either of these plans fulfilled. The Earl of Morton, on visiting his estates in Orkney and Shetland, in 1739, wished to settle the geography of those islands, which had hitherto been set down most erroneously in all maps, and applied to Maclaurin on the subject. He was unable at that time to undertake a journey to those remote isles; but he drew up a plan of what he thought necessary to be observed, furnished the proper instruments to survey the coasts and ascertain the meridian, and recommended Short, the celebrated optician, as a proper person to undertake the survey, through having a deep personal interest in geography. We are told, that "after carefully perusing all the accounts of voyages both in the South and North Seas, he was of opinion that the ocean was most probably to be found open from Greenland to the South Sea, by the North Pole; and when schemes for finding out such a passage were submitted to Parliament in 1744, he was consulted concerning them by several persons of rank and influence; but before he could furnish the memorials which he proposed to have sent, the premium was limited to the discovery of a North-west passage, and Mr. Maclaurin used to regret that the word *west* was inserted; for he thought a passage, if at all to be found, must lie not far from the Pole."

In 1745 he was very active in making plans for the defence of Edinburgh against the Highlanders, to whom its gates were peacefully opened, without a shot being fired; and as Prince Charles Edward, after his victory at Prestonpans, found himself in sufficient strength to punish, if he chose, those who had been active in the Hanoverian cause, he ordered all who had been volunteers for the defence of the city to subscribe a recantation of what they had done, under pain of being treated as traitors to James VII.

Maclaurin thus found himself in some peril, and fled to England before the last day of receiving the submissions; but not before he had found means to convey a good telescope and a supply of provisions into the Castle of Edinburgh, where some companies of the 47th Regiment, and other fugitives, were blocked up by the Highland clans. Dr. Herring, then Archbishop of York, hearing that Maclaurin had taken refuge in the north of England, invited him to reside with him while in that part of the country. On his journey southward he had a severe fall from his horse; and on his return home after the Highlanders marched into England, having been exposed to excessive cold

and tempestuous weather, he became seriously indisposed, and he was soon discovered to be suffering from dropsy in the abdomen. For the removal of this he was thrice tapped in vain, and it became evident, all medical skill having failed, that he would sink at last; but he remained calm and cheerful even to the end. When engaged in dictating to the amanuensis, whom he was now compelled to employ, that last part of the last chapter of his "Account of the Discoveries of Sir Isaac Newton," in which he proves the greatness and goodness of God, his voice was observed to falter, and his face grow pale. Dr. Munro was promptly in attendance; but the great mathematician breathed his last on the 14th of June, 1746, aged forty-eight years and four months. He lies interred in the Greyfriars Churchyard, where his son, John, Lord Dreghorn, erected the monument which still covers his remains.

The writings of Maclaurin were numerous, and his researches were deep. In 1740 he sent a paper to the Royal Academy of Sciences at Paris, on account of which he shared—as already stated in the TECHNICAL EDUCATOR—the prize of the Academy with Bernouilli and Euler, for solving the problems relating to the motion of the tides, from the theory of gravity—a question which had been given out during the former year without receiving any solution. Among his many contributions to the *Philosophical Transactions* were papers "On the Construction and Measure of Curves;" "A New Method of describing all kinds of Curves;" "On Equations with Impossible Roots;" "An Account of the Annular Eclipse of the Sun at Edinburgh, 27th January, 1742-3;" "A Rule for finding the Meridional Parts of a Spheroid, with the same Exactness as of a Sphere," etc. etc. After his death, his "Treatise of Algebra," and his "Account of Sir Isaac Newton's Philosophical Discoveries," were published by his friends in 1748. Subjoined to the latter is a Latin tract, "De Linearum Geometricarum Proprietalibus Generalibus," on which his last hours were employed, and which was his farewell legacy to science.

CIVIL ENGINEERING.—XXV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

WE now pass on from the centering of an arch to the arch itself, our subject for the present being *masonry* bridges.

In arranging for the construction of a bridge, it is seldom that the engineer has a choice of ground; for the position of the bridge must be decided upon rather with a view to the requirements of traffic than to the suitability of the site. However, if the selection of the locality depend in any way upon the engineer, he will not fail carefully to examine the width of the river, the character of the banks, and, above all, the nature of the bottom. Whenever practicable, the position of the roadway should be laid directly across the stream, and a diagonal or *skew* bridge be thus avoided. The *height* of the roadway, and particularly the height of the water, either at extremes of tide if it be a tidal stream, or during floods if it be a fresh-water river, must be properly studied; and if more than one arch be required to span the stream, then the volume of water at extraordinary periods should be ascertained, as well as its rapidity, in order to guard against accident and obstruction in determining the size and shape of the piers. Some of the following observations are from a work on bridges, by M. Gauthey.

In no stream, whether tidal or otherwise, is the volume of water passing any given spot equal at all periods. The span and water-way of the bridge should therefore be wide enough to afford room for the superabundant quantity arising from floods, and it will be found that this quantity bears some proportion to the surface of the land which is drained off at that point of the river's course where the bridge is proposed to be erected; it is also very necessary to ascertain carefully the velocity with which the water, during a flood, travels past the spot. As the velocity of a stream varies at the surface and the bottom, both must be ascertained, and a mean obtained. If the velocity at the surface in inches per second = V, the velocity at the bottom may be represented by $(V+1) - 2\sqrt{V}$, and the mean velocity by $(V + 0{\cdot}5) - \sqrt{V}$. The following table of velocities is calculated upon the basis of these formulæ, and is practically correct:—

Surface.	Bottom.	Mean.	Surface.	Bottom.	Mean.
4	1.0	2·5	52	38·5	45·2
8	3·3	5·6	56	42·0	49·0
12	6·0	9·0	60	45·5	52·7
16	9·0	12·5	64	49·0	56·5
20	12·0	16·0	68	52·5	60·2
24	15·0	19·5	72	56·0	64·0
28	18·4	23·2	76	59·5	67·7
32	21·6	26·8	80	63·1	71·5
36	25·0	30·5	84	66·6	75·3
40	28·3	34·1	88	70·2	79·1
44	31·7	37·8	92	73·7	82·8
48	35·1	41·5	100	81·0	90·5

Another formula for velocity is as follows:—

V = velocity at surface.
W = a constant number = 0·02707 metres.
U = the mean velocity.

$$U = (V - \tfrac{1}{2}W)^2 + \tfrac{1}{4}W.$$

The above is by Dubuat, but M. Prony has adopted another and a more correct one:—

$$U = \frac{V\,(V + 2{\cdot}37187)}{V + 3{\cdot}15312};$$

or $U = \frac{4}{5}V$ may be considered sufficiently correct in practice. It is obvious, however, that particular cases will occur of extreme rapidity or peculiar formation of the bed of the river, in which no stated formula will hold good; and the engineer must in such cases—and indeed it would be safer to add in *all* cases—depend upon his own observations and experience rather than upon the observations of others.

In constructing a bridge, attention must be paid to the velocity with which the water will move under the arches at particular periods, and this velocity must not be allowed to be such as to cause the current to attack the bed of the river, and to injure the foundations of the piers and abutments. The nature of the bottom becomes an essential element in the case, as it may be either rocky or of sufficient tenacity to prevent the flow of the current from acting upon it; or it may be sandy and yielding, and in such a case it may be necessary to form an artificial bottom of piling and ground timber.

It is of course impossible to erect a pier in the bed of a river, or abutments projecting into the stream on either side, without causing more or less of an obstruction; and it becomes the duty of the engineer to determine as nearly as possible what amount of obstruction will result from the particular piers and abutments he purposes erecting. It is a problem which cannot be very accurately solved, but may be approximated:—

Let V = velocity of river in feet per second previous to the obstruction.
,, A = sectional area of river in feet unobstructed.
,, a = sectional area at the point of obstruction.
,, R = rise of water in feet caused by the obstruction.

$$\text{Then } R = \left(\frac{V^2}{58{\cdot}6} + {\cdot}05\right)\left(\left(\frac{A}{a}\right)^2 - 1\right).$$

The following table of rise of water caused by obstruction will be found of use:—

Velocity in feet per second (V).	Rise in feet when amount of obstruction as compared with sectional area of river (A) =								
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
1	·01	·03	·06	·11	·20	·35	·67	1·60	6·63
2	·02	·06	·12	·21	·35	·62	1·19	2·83	11·70
3	·04	·11	·21	·36	·61	1·06	2·05	4·88	20·15
4	·07	·18	·33	·57	·97	1·70	3·27	7·77	32·07
5	·11	·27	·51	·87	1·48	2·60	5·02	11·91	49·15
6	·15	·37	·59	1·18	1·99	3·48	6·71	15·93	65·75

It should be remembered that the velocities of a stream are in an inverse ratio to the areas of the corresponding sections.

The form given to the "starlings," or projecting ends of the piers of a bridge, exercises a considerable influence upon the manner in which the natural flow of a current is affected on meeting the obstruction. If we take unity to represent perfect obstruction at the pier, we may consider that produced by a starling whose form is semi-circular, or an acute angle $= \frac{1}{20}$; if the form be an obtuse angle, it will $= \frac{1}{10}$; if square, it will

$= \frac{3}{20}$; and if the arches are small, and their springing is under water, it will $= \frac{3}{10}$.

The forms of the arches of bridges are very various. They may, however, be grouped as follows:—Semi-circular; those formed by the intersection of two similar curves; those approaching more or less to an ellipse; and those consisting of a part of the circle. It is remarkable that in the most ancient bridges the semi-circular form has invariably been adopted. It forms the strongest arch which can be constructed; but in consequence of the height of the versed sine, which is equal to the radius, and therefore to half the span, it becomes necessary, in order to restrict the height of the roadway, to limit the span, and consequently to increase the number of arches, and correspondingly to diminish the water-way. Besides this objection, the springing of the arch requires to be very low, frequently below the water-line, and hence the obstruction is still further increased. All these objections are removed by the employment of a flat arch—that is, a segment of a large circle, or the intersection of two such segments. It was not, however, until the end of the seventeenth century that flat arches were introduced.

Whatever be the curve or curves given to the arch, it is desirable that the tangent at the summit should be horizontal; hence the Gothic arch, although beautiful in architecture, is not suitable for a bridge. The curve of an arch other than a semicircle, or arc of a circle, should consist of not less than three segments of circles.

When an arch is to consist of several segments of circles, it becomes necessary to obtain some means of determining the centres of those segments, so that some regularity shall exist in the gradual alteration of position of the tangents from the vertical at the springing to the horizontal at the crown. It is not intended to lay down any particular rule for this, neither is it necessary; we shall satisfy the requirements of the case by pointing out the course which has been pursued in certain cases.

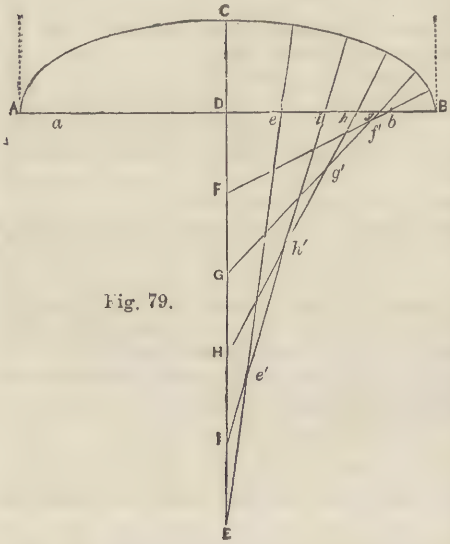


Fig. 79.

In the case of the bridge of Neuilly, commenced in 1768 by Perronet, a bridge justly admired for the beauty of its design, the arches are 128 feet span, and their springings on a level with low water. The form of the arches is elliptical, and the curves of their centres were struck as follows:—

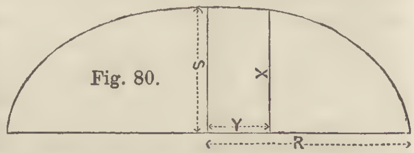
Let A B (Fig. 79) represent the chord line or greater diameter of the intended arch, and a b the centres of the curves at the springing, ensuring the verticality of the tangents at this point. Let C be the height of the crown of the arch, and prolong C D to any point E, making D E a multiple of D b (in the case of the bridge at Neuilly this was triple), and divide D b, D E into the same number of parts (in this case five), making the parts on D E equal, and those on D b in the proportion to each other of 1, 2, 3, 4, and 5, and join the points of division by the lines F b, G g, H h, I i, E e; then the respective points of intersection of those lines, E, e', h', g', and f', will be the centres of the different arcs which compose the arch, each arc being bounded by the prolongation of the lines F b, G g, etc. In adopting this plan for the formation of the curve, it will be seen that we started with fixing the points a and b arbitrarily upon the line A B, and that all the other steps are dependent upon the position of these two points. In practice, however, it is usual to decide beforehand what shall be the relative values of A B and C D; therefore, as certain points in the curve have become fixed, it will be found necessary somewhat to modify the respective segments so as to ensure C D remaining at the required height.

An ellipse may be constructed by ordinates, and the lengths of the ordinates be calculated by the following formula:—

Let R (Fig. 80) = semi-transverse axis; S = semi-conjugate axis; X = length of any ordinate; Y = distance of ordinate from centre.

$$\text{Then } X = \sqrt{S^2 - \left(\frac{S\,Y}{R}\right)^2}.$$

As the lengths of the ordinate in an ellipse bear always a definite proportion to the length of the semi-conjugate axis, it is easy to assign a value to this proportion taken in certain fixed positions along the semi-transverse axis, which in fact becomes half the span of the bridge whose arch has the elliptical curve.



Supposing, then, that the semi-transverse axis be divided into ten equal parts, the length of the ordinates at these points will be as follows, the length of the semi-conjugate axis being taken as unity. Commencing from the centres, the values would be, the semi-conjugate axis being 1·0—

No. 2 = ·9949.	No. 5 = ·9165.	No. 8 = ·7141.
„ 3 = ·9797.	„ 6 = ·866.	„ 9 = ·6.
„ 4 = ·9639.	„ 7 = ·8.	„ 10 = ·4358.

We have been careful to draw attention to the form of the curves of arches, as so much of the beauty of a bridge depends upon the character of the arch.

As we have no room to consider the mode of construction of masonry bridges, we will conclude this chapter with one or two extracts which show the extreme necessity that exists for providing a sufficient water-way.

In 1822 floods produced by excessive rain occurred in Scotland. Rivers assuming an aggregate length of upwards of 500 miles were flooded, and the whole of their courses were marked by the destruction of bridges and other impediments. Sir T. D. Lauder, in his account of this flood, records the destruction of thirty-eight bridges. The bridge over the Dee at Ballater consisted of five arches, with a total water-way of 260 feet. The bed of the river on which the piers rested was composed for the most part of granite, of which material the bridge itself was built; but after standing uninjured for twenty years, the different parts were swept away in succession by this flood, and at last the whole mass disappeared in the bed of the river.

In 1827 heavy rain occurred on the Cheviot Hills, and a small stream called the College was so swollen thereby that a bridge in course of construction was carried away, some of the voussoirs of which weighed from 10 to 15 cwt. It may be argued that these were exceptional cases; but as they are known to occur, it becomes only an act of prudence to prepare against every probable eventuality.

The friction of running water against the bottom and sides of the bed of a stream is another source of danger to bridges, which, as we have already pointed out, can best be met by piling. The fact that the surface of a stream moves more rapidly than the bottom, and the centre of the surface than those portions near the banks, is due wholly to the retardation caused by friction against the sides; and it has been ascertained by observation that a velocity in the stream of only three inches per second against the bottom is sufficient to tear up and remove fine clay, whereas six inches per second will remove fine sand, twelve inches per second fine gravel, and three feet per second stones as large as an egg. It is no cause of wonder, then, that where insufficient precautions are adopted with respect both to the water-way and the channel of a bridge, damage will frequently arise. The whole channel of the St. Lawrence, from the Niagara Falls to the town of Queenstown, a distance of seven miles, presents an instance on a grand scale of the power of running water to cut away the bed along which it flows. In France many valleys are to be found where the channels of rivers have been barred by currents of solid lava, but through which the streams have re-cut a passage for themselves, in some instances to great depths.

HOROLOGY.—V.

By I. Hermann, late Teacher of Technical Science to the British Horological Institute.

THE DUPLEX ESCAPEMENT.

We now proceed to a description of the duplex escapement. In the first escapement described we have the pallets shutting off, so to speak, the rotary or centrifugal force of the escape-wheel for regular intervals, during which the balance moves as free of the escapement as if it was a mile away from it; and in the chronometer we have the detent doing the same office. In both these escapements there is this intermediate mechanism, by which the balance is kept totally detached from the rest of the mechanism of the watch during a definite angle of its vibration.

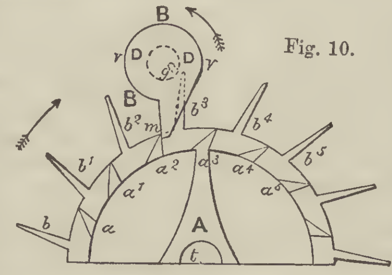


Fig. 10.

A mere glance at Fig. 10—being the plane of the duplex—will at once discover the absence of any such intermediate or third piece in addition to the escape-wheel and balance; and hence the centrifugal force of the escape-wheel, which is equal during motion or repose, is acting and pressing against a section of the balance during all its motion over and above the arc of impulse, in the same ratio as the lever escape-wheel presses against the locking, or the chronometer wheel against the pallet of the detent; and hence the balance stands in the same relation to the escape-wheel as the pallet and detent to the respective wheels of the former escapement, and for this principle is undetached.

Proceeding to definitions of our illustration, we have in A a section of the escape-wheel, having fifteen horizontal teeth, represented by b, b^1, b^2, b^3, and so on, and fifteen vertical teeth, delineated at a, a^1, a^2, a^3, and so on. Its appliance to the escape-pinion is by the concentric hole t, in the same manner as described by the other escape-wheels. B B is a piece of steel of the given shape, fixed to the balance in the manner of lever or chronometer roller, and concentric with its boss, v v, and is called the duplex pallet.

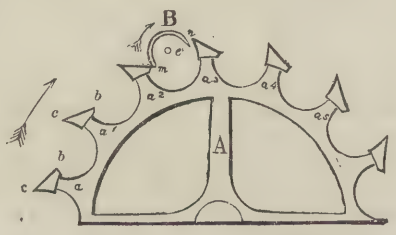


Fig. 11.

Below the pallet is a jewelled roller, represented by the dotted circle D D, fixed also concentric to the balance, and called the ruby-roller. It has a notch at g, of minimum width of the thickness of an escape-tooth. In the elevation of this escapement the horizontal teeth, b, b^1, b^2, etc., are in plane or level with the ruby-roller. Above these teeth, which are on a level with the rim of the wheel, is the pallet B B, sufficient clearance being left to prevent its contact with the rim of the escape-wheel, or teeth b, b^1. Projecting at right angles to the rim, and above the pallet B B, are the vertical teeth a, a^1, a^2, etc. The positions of balance and escape-wheel are determined by jewel-holes, in the same way as the lever or chronometer escapement.

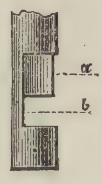


Fig. 12.

The action is as follows:—The escape-wheel, moving in the direction as indicated by the arrow, is in contact with face, m, of pallet, B B, by its vertical tooth a^2. The condition of this contact is again that of two intersecting arcs; and hence when by the rotation of wheel and pallet the point of intersection is reached, tooth a^2 becomes disengaged from the pallet-face m. The escape-wheel now moving freely, brings tooth b^2 in contact with the circumference of the ruby-roller, D D, by which it is arrested during the completion of one and part of another vibration of the balance. The minimum width of the roller-notch g being equal to the thickness of a tooth b, plus its clearance, when on the return motion of the balance this notch, g, in the roller, D D, repasses the periphery of the escape-wheel (the contact of wheel and this roller being also proportioned to two intersecting), arcs a drop or forward motion of the escape-wheel takes place, equal in its angular measure to the span of the notch g, which brings the tooth b^2 in contact with the side of the notch that faces the direction of the escape-wheel. This motion gives a decided check to the balance. The radius of the roller being small, and the centrifugal force of the wheel inversely proportioned to the radius of its teeth, it is not sufficient to stop the balance; but the force of the wheel is overcome by the balance-momentum, and forced or propelled back until the end of the side of the notch in contact has passed the periphery of the escape-wheel, and so the point of tooth b^2 is again resting on the roller circumference, and the vibration proceeds.

The contact of the escape-wheel and the roller D D being proportional to two intersecting arcs, when therefore, on the return motion of the balance, the notch enters the periphery of the escape-wheel, the tooth b^2, without any drop, passes off the circumference on to the side of the notch last in contact, and moves simultaneously with it, until the point of intersection is again passed, and tooth b^2 becomes disengaged from the roller-notch g. At this stage the end of pallet B B has entered the periphery of the vertical tooth a, by about one degree measured from its centre. The escape-wheel being free to move, a slight drop takes place, which brings tooth a^1 in contact with the face m of pallet B B, as illustrated in our diagram, when the impulse-action first described re-commences, and so on to the repetition of this action, as long as the watch is wound up.

It will be noticed that we have here four relative radii, namely, those of teeth a and b, and of roller and pallet. It is the ratio of the pallet-radius, B B, and vertical tooth, a, that determines the impulse-angle, and *vice versâ*. There is no definite angle adopted in its manufacture or construction: the angle, indeed, varies from 30° to 40°, and even 45°.

The angular impulse-motion of the escape-wheel is considerably less than the measure of two teeth, which is equal to the chord of the intersecting arcs of roller D D and tooth b; plus the drop off the pallet-face, m, on to the roller, and off the latter on to the former.

One of the chief conditions of error is the pressure of the teeth b, b^1, etc., against the roller during the vibrations, and this pressure is again proportioned to the roller-radius. Hence it is an advantage to make this radius at a minimum, thereby reducing the factor or coefficient of resistance; this minimum is, however, limited by two conditions. The roller, D D, is connected to the staff, which passes through a small hole in its centre, and hence the staff will require to be thinned in proportion to the diameter of the roller; and considering that this is the axle of the balance, certain stability must remain, and thus a limit is given to the roller-diameter. In addition to this limit set by the build of the escapement, there is another by the mechanism of this contact.

The balance-arc from the point of entry of tooth b into the notch g, to the point of its exit, depends upon the relative distance in plane of the two centres; and as in this escapement, the same as in the chronometer, impulse is only given once every two vibrations, and the escape-wheel is in repose until the notch g passes the periphery of the teeth b, b^1, etc., and cannot give impulse till then, it follows that in proportion to the intersection so is the angular measure from the roller-centre, and so has the balance to describe an arc from its repose before it can receive impulse-contact. The greater this angle the more the watch with a duplex escapement is inclined to set; and, inversely, the smaller this angle the less this inherent error asserts itself.

But as the measurement of the roller-resistance to the escape-wheel is the depth of the two intersecting arcs, and this depth diminishes by a diminished roller-angle of the intersections, we get a very delicate wheel, and roller-contact by a smaller roller,

and hence multiply the chance of error in this direction in two-fold ratio.

On the other hand, by making the roller-diameter too large we increase the co-efficient of resistance, and with it, and in proportion to it, diminish the impulse-angle of the escape-wheel. As in circles of different radii, the arcs that subtend them vary as their radii, so we have in a larger roller a longer chord of the intersection by roller-contact, and hence a greater angular motion of the escape-wheel during the roller engagement. The angle of two teeth of a fifteen-tooth wheel is 24°, and one degree of drop on to the pallet and one off leave 22°, from which has further to be deducted the angle of its motion during roller-contact, and hence the larger the diameter of the latter the less the angular motion left to the escape-wheel to give impulse.

These are, therefore, the two points of limit to the minimum and maximum roller-diameter, and experience determines them between one-third and one-fourth the space of two points of the horizontal arcs.

When we, therefore, wish to determine the relative ratio of the radii of the vertical teeth a, a^1, etc., and pallet B B, we must ascertain the impulse-angle of wheel that is left after deducting its three foregoing motions. This would lead us to mathematical formulæ not in keeping with our papers on this subject, and hence we will only trace out a few points to be observed as being of most importance.

The arc of wheel and roller intersection is completed before the impulse-contact of wheel and pallet commences, and as the termination of the roller-contact is at the point the impulse-contact commences, it follows that the greater the chord of the arc, and with it the angular measure, the further the balance has to move before the points of teeth b, b^1, etc., can enter the roller-notch, the point of this entry being the opposite intersection of the roller-contact.

The impulse-arc of the escape-wheel is measured from the end of either of the vertical teeth a, a^1, etc., in a direction opposite to its direction of rotation. That is to say, when the wheel is at repose against the ruby-roller, and a line is then drawn between the two centres, the distance from this line to the next tooth, measured in the direction the wheel is moving, is half the angular measure of its impulse, plus the drop; and hence the distance from this line to the next tooth in the opposite direction is half the impulse-angle plus the roller-angle of contact, plus the drop. It follows from this that the position of the vertical tooth leaving the impulse-contact is determined by the roller-arc of intersection, and consequently also the length of pallet. By making this arc of roller-contact at a minimum, we are thereby enabled to reduce the tendency for setting on the one hand, and increase the impulse-angle of wheel and length of pallet on the other.

It is desirable to have a wide notch in the ruby-roller, rather than a narrow one, because the angular motion of the balance required in excess of the position of the pallet in the periphery of the escape-wheel is such as to allow the long or star teeth, b, to enter the notch. By examining our illustration, it will be easily observed that with a wider notch this effect would be obtained with a shorter balance-motion, and is therefore again of important advantage as regards setting.

This escapement is of the most delicate nature, scarcely less delicate, indeed, than the chronometer. It will easily be conceived that if there is any or the least difference in the lengths of the star-teeth b, b^1, etc., the variation in the balance-angle of roller-contact between the shortest and longest tooth is very great, and hence there is a corresponding variation in the balance-arc of impulse; because by the longer arc of roller-contact we get an excess of drop on to the face, m, of the pallet, or inversely, by a shorter tooth the roller-contact ceases before the pallet enters the periphery of the wheel, and so loses impulse-contact entirely. The careful adjustment of the equality of the lengths of those teeth is therefore of great importance; or, in other words, the escape-wheel requires to be most accurate in its truth. In consequence of the delicacy of this roller-contact the balance-pivots require most careful adjustment in the jewel-holes, as every side-movement of the pivots in bad-fitting holes produces errors in consequence.

This escapement, which although simple, yet requires great skill in making, is expensive for the manufacturer, and, by reason of its delicacy, is also costly to the wearer of a duplex watch; hence it is fast going out of date as a popular portable timekeeper, and is in this sense succumbing to the more favoured lever escapement. And being undetached, it falls short of the properties required in the escapement of a more perfect watch, and hence it is not only manufactured at a very small rate, but is often taken away to have its place supplied by the lever. This is, however, more often done than needful, for when carefully attended to it gives very excellent results, and its deficiency is more often than it ought to be the result of ignorant and unskilled labour, and so has to bear the contempt that justly belongs to the man who passes under the popular term watchmaker, but who is in this case misnamed.

THE HORIZONTAL ESCAPEMENT.

Our illustration (Fig. 11), shows the plan of this escapement. The escape-wheel, which is applied to the pinion in the manner of the former ones, is shown at A, and its teeth at a, a^1, a^2, etc., of which in modern watches there are mostly fifteen. By virtue of its construction, the escape-wheel forms the principal section. The face of each tooth, b c, forms an inclined plane with the direction of its rotary motion, which, being movable, comes under the modification of a wedge. B is the plan, and Fig. 12 the elevation of the cylinder. Its form is that of a hollow cylinder, solid at each end, into which two pivoted plugs are driven. Vertically, its central part has two-fifths of its circumference cut away, as shown in B and a (Fig. 12); and at b (Fig. 12) it is further reduced, leaving only as much of the tube as to keep its upper and lower parts firmly connected. The parts c b of the escape-teeth are elevated above the rim, and connected with it by a foot or stem. The action of its mechanism is as follows:—The wheel is moving in the direction indicated by the arrow. The point of tooth a^2, answering to b of tooth a^1, is in contact with the circumference of the cylinder B, which is rotating about its centre e, and in the direction indicated by the adjacent arrow. The escape-wheel is in repose until the section m of the cylinder B has passed the circle drawn through the point b, when the wheel moves on with a constant velocity, until section m has passed the periphery of the wheel, when a short drop takes place on to the inside of the cylinder, such drop being no more than is necessary to give sufficient clearance to the tooth inside the cylinder, and the cylinder between the teeth. On the return motion of the cylinder, we have a repetition of the action described on section n of cylinder B, and so on alternately.

This alternate contact of cylinder section m n, and the inclined plane, b c, of the escape-teeth being the impulse, it will readily be seen that the measure of the impulse-arc of the cylinder depends upon the angle of b c with the direction of the wheel. In detached escapements it is desirable to reduce the arc of impulse to a minimum, but here it is the reverse; because in the former the arc in excess of impulse is free, but in the point b it is exerting a constant pressure against the surface or the hollow of the cylinder; hence the balance vibrates freer during the interval of impulse than during the repose of the wheel. Much might be added on the conditions underlying this fact, as well as on the curve that the incline b c sometimes takes, but such is beyond the limit of these papers.

No definite ratio exists between the radii of the cylinder and the wheel. If the circumference of the cylinder were a line according to Euclidean definitions—that is, without breadth—then its diameter would be half the measure of two teeth. It follows, therefore, that the thickness of the cylinder-tube determines the ratio, and the more solid it is, the smaller the ratio between tooth and space.

We must refrain from entering on these conditions and their effect, and will only add that in practice a cylinder should be selected that gives a good clearance for the tooth inside, and on each side. The relative positions in plane for wheel and cylinder should be as distant as possible in portable escapements to prevent setting, the condition of limit being the point of contact after drop, such being firmly on to the circumference, but no more than safe.

The vertical position of the teeth is at a (Fig. 12), and that of the rim at b. In this escapement it is necessary to limit the motion of the balance to one half turn, measured from its repose, which is technically called "banking," being effected by a pin inserted in the balance and another at an angle of 180°, thereby permitting the balance to vibrate half a circle.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Galletly, Curator, Industrial Museum, Edinburgh.

VII.—MANUFACTURE OF CARPETS.

First in order, as regards the length of time they have been in use, as well as on account of their simplicity, beauty, and intrinsic value, we require to take the carpets of India, Persia, and Turkey. Though the high artistic taste displayed in these is not equally good for all three countries, yet they have a great deal in common, and are all made on the same principle, which is an exceedingly simple one. The loom is commonly of the most primitive kind, consisting of two posts, fitted, at a suitable distance apart, with a beam or roller at the top and another about two feet from the ground. Between the two beams hang, vertically, the warp threads; and each coloured tie or tuft of wool passes across two of these and has the ends drawn up between them, so as to form a kind of knot, like that shown in Fig. 36, or of some equally simple kind. When a row of these ties is completed, a "shed" is formed in the warp by means of the "heddles," and a weft thread thrown across from right to left and returned, so as to bind the tufts firmly into the fabric, the weft being beat close up by an instrument called a "lay." Another row of coloured tufts is then knotted or twisted in, another weft thrown, and so, with the aid of a drawing, and sometimes without it, the slow and tedious work goes on. The carpet is wound up bit by bit, as it is woven, on the lower beam. It is obvious that by this plan there is practically no limit either to the kind of design, the number of colours, or the size of carpet which may be adopted. Some carpets are, however, made in India on horizontal, and perhaps more primitive, looms, in which there are no treadles to raise and lower the warp strings. In these the weft is not thrown across with a shuttle, but is passed through the warp by several workmen, the narrowest piece requiring two, and a very wide one eight or ten to conduct the weaving.

Such are the rude and simple methods by which what are by far the most beautiful and durable carpets in the world are made; but the process is so slow and laborious that objects so woven must needs be very costly. Occasionally an Indian rug or small carpet will bring as much as three hundred pounds, and one carpet made in Cashmere of fine goat's wool was sold in Paris in 1867 for more than double that sum. So high is the artistic merit of these fabrics that European manufacturers are considered to have improved their designs within the last twenty years far more than at any former period, chiefly through introducing something of the spirit and appropriateness of Eastern patterns into their productions. Dr. Forbes Watson gives a curious illustration of what is likely to result from the contrary practice of getting Indian workmen to imitate European designs. He says: "A striking instance of this was afforded by a large carpet made in one of our Indian gaols of Berlin wool, and sent to the International Exhibition of 1862. The pattern consisted of big roses and other flowers grotesquely distorted, and was, we believe, considered quite a *chef d'œuvre* by the gentleman who directed and superintended its execution. At the termination of the exhibition it sold for less than the original cost of the wool."

Considerable numbers of Indian rugs and carpets are now sent to Europe, but the commerce in Turkey carpets is much more extensive. These are chiefly made at Oujak, in the neighbourhood of Aidin, and exported from Smyrna. Similar carpets are made in Algeria, Tunis, Russia, and Holland. The English Axminster carpet is also a costly hand-made fabric of the same nature, the manufacture of which is, or not long ago was, carried on in a single establishment at Wilton, whither this limited branch of the carpet trade was transferred some thirty or forty years ago. Aubusson carpets, so long and so highly esteemed in France, are likewise hand-made; but the peculiar nature of the design, as well as the fine texture of these fabrics, render them more of the character of tapestry. Without saying more about these high-class goods, we now proceed to give an outline of the manufacture of the more common but still beautiful kinds, and shall begin with the

Kidderminster or Scotch Carpet.—This is the oldest kind of our ordinary carpets, and although no longer manufactured at Kidderminster is still largely made in Durham and Yorkshire; and in Scotland at Kilmarnock, Bannockburn, Aberdeen, and a number of other places. The "Scotch" differs from all other descriptions of carpeting in having, like a damask of more than one colour, a similar pattern on both sides so far as outline is concerned, but with the colours reversed. Thus if on one side a leaf appears red on a green ground, on the other it will appear green on a red ground. A real Scotch carpet is all wool, but fabrics similar in appearance are made with cotton warps and worsted wefts, in which case they are called "unions." In thickness it consists either of two or of three layers of cloth, and according to which it is named a two or a three-ply carpet. The so far separate layers are united at many different points, because the yarns, according as their colour suits any particular section of the pattern, sometimes form part of the upper, sometimes of the lower web; or if it is a three-ply, each thread is partly woven into all three layers. Both two and three-ply carpets may be wrought with only one colour of weft, in which case the figures in the pattern are formed by the warp threads. When this is done, the warp yarns are made much thicker than those for the weft, and for this reason: if the colours used are only three—say black, red, and green—and black is chosen for the weft, then, as this has to cross every flower or leaf of red and green, it must tone down their brightness; at the same time it intensifies the black spaces, just as a red weft would intensify the red spaces. Plainly, therefore, the thinner the weft thread, compatible with strength, the better. However, all the best carpets are made with as many colours in the weft as there are in the warp, but, of course, at some additional expense. A Scotch three-ply, if made of thoroughly good material, though wanting the rich appearance of a "Brussels," is one of the most durable carpets made, besides possessing the advantage of having two sides or faces, one of which can be made to look very different from the other, although both have the pattern the same in outline. Jacquard looms, or rather looms fitted up with Jacquard apparatus, are now almost entirely used in weaving Scotch as well as Brussels and Wilton carpets.

Venetian Carpeting, so much used for stairs, resembles Scotch in appearance, but being usually made with some simple pattern, and this being formed entirely by the warp threads, it can be woven on common looms. The weft is concealed, and is of linen or hemp. A similar but coarser kind called *Dutch* carpeting is, however, made with worsted weft.

Brussels Carpet.—Very much as silk velvet is richer looking than plainly woven silk does the so-called "Brussels" carpet excel in appearance the Scotch or Kidderminster. This variety of carpet appears to have been introduced into England nearly a century ago, and is more largely made than any other kind of our better class carpets. As some other varieties about to be noticed more or less resemble "Brussels," we shall explain its structure fully; and as it will help to make this, as well as the nature of the weaving in the others, more clear by comparing them with plainer textures, we give a few diagrams illustrating these. Figs. 37 and 38 show plain, and Figs. 39 and 40 twilled weaving. Fig. 41, again, shows the structure of velvet. Brussels carpet is not unlike velvet in its character, as will be seen by examining Fig. 42, which is a face view, and Fig. 43, which is a section across the weft of a fragment, both being double the actual size. In Fig. 42 the portion marked A represents the finished pattern, which, let it be understood, is entirely formed of the *woollen* warp. The other portion, B, shows the *flax* warp and weft threads only; but we may take the tinted interspaces in the latter to be made up of the woollen warp threads stretched quite straight, in which case it would represent the appearance of the back of the carpet at all times and of the face too, if we choose to pull down the loops seen in Fig. 43 which rise at intervals, according to their colour, to form the pattern. The upper and under rows of weft threads (*w t*) thus enclose between them a certain number of coloured woollen warp threads, and the whole fabric is bound together by the double lines of linen warp marked *l w* in the figures. In weaving Brussels carpet the coloured warps are arranged in bobbins set in frames at the back of the loom. There is usually a separate frame for all the bobbins of one colour, and according to the number of colours in one line—say the line C D—the fabric is styled a two, a three, or a five-frame carpet. The peculiar and most complicated-looking loom on which these are woven has a Jacquard mounting, which raises at one movement all the proper warp strings, that is, those, and those only, which suit that section of the pattern across the breadth of the web. A wire is now

inserted to form the loop, which is then bound in by linen weft, for which, by suitable "harness," there is the necessary "shed" made in the linen warp as well. Another set of coloured warp strings are next raised, another wire inserted, another tie of linen weft and warp made, and so on. Only a limited number of wires are required, and there is a motion for withdrawing the one farthest back and re-inserting it in front as the weaving proceeds. The "wiring" process has been recently simplified by the application of magnetism. Three of these wires are shown in position on the left of Fig. 43. It should be clearly understood that whenever there are, say, five colours in one line, all the five warp threads are present throughout its length, although only one comes to the surface in the form of a loop or loops at a time. Supposing the worsted warp to be of the same size and quality in both cases, a five-frame carpet would therefore have more threads packed into a given space than a three-frame one, and consequently it has so much more wool in it. A good figured Brussels, 27 inches wide, requires some 1,300 bobbins of coloured warp threads.

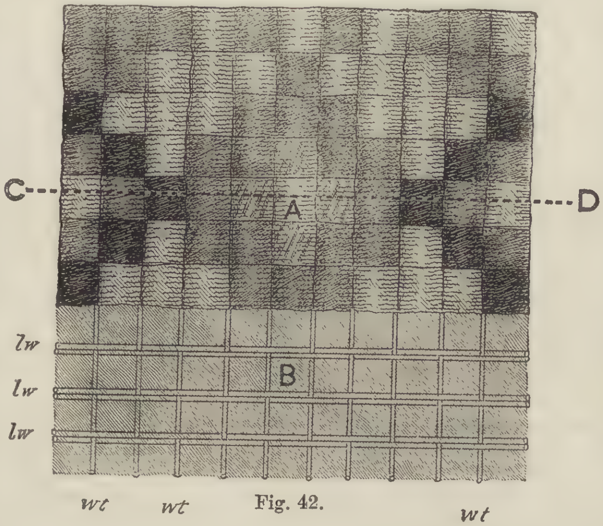


Fig. 42.

Velvet-pile or Wilton Carpet.—The structure of this carpet is almost the same as a Brussels, the chief difference being that in the "pile" the loops are cut, so that it still more closely resembles velvet. In order to facilitate the cutting of the loops, the wires used in weaving pile fabrics have a groove on their upper edge, along which a knife is drawn. As in the case of velvet itself, this kind of carpeting requires to be cut on a spiral or other cutting-machine, so as to reduce the surface to a uniform level. The upper weft threads in a pile carpet are usually twice as many as in a Brussels, in order to hold in the cut tufts very tightly, as will be seen by comparing Fig. 44 with Fig. 43. Wilton carpets, being generally made of finer yarn, besides being altogether a more expensive manufacture than Brussels, sell at a correspondingly higher price. The chief seat of both Brussels and velvet pile carpets in Great Britain is Kidderminster, where there are at present in operation about 900 power-looms, the trade there employing in all not less than 3,000 work-people. A few hand-looms are also still at work in the town.

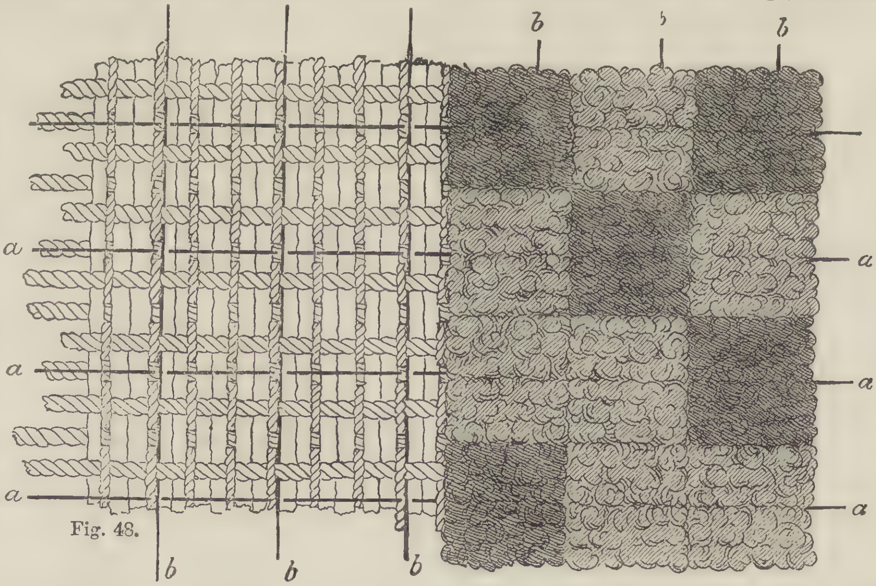


Fig. 48.

Tapestry, or Printed Warp Carpet.—In the year 1832, Mr. Richard Whytock, of Edinburgh, patented a method of imitating Brussels carpet with parti-coloured warp yarns, which has been of greater service to the carpet industry of the country than any other improvement of modern times. The invention is one of great ingenuity and simplicity, and so entirely original that the patent, notwithstanding its brilliant success, was allowed to run its course without any of those legal contentions which so commonly attend profitable patents. It was even renewed for five years after the expiry of the usual term of fourteen years. The structure of this fabric closely resembles that of a Brussels carpet, as the two figures 43 and 45 will show, Fig. 45 being the tapestry carpet. Both have their pattern entirely produced by the warp, but on Whytock's plan a single warp thread does what it takes a number to do in a Brussels, and this is effected in the following way:—To save making another figure we shall now suppose that Fig. 42 represents a fragment of Whytock's tapestry carpet, and that along the line C D there are five colours, then the single warp thread which travels along this line is printed red for a certain length, green for another, it may be a greater or a smaller length, and so on with orange, blue, and black, taking these to be the five colours. In this way one thread will do lengthwise, however many colours are required, but no two threads with the coloured spaces exactly alike go together, because in the case of a red flower, for example, where a thread passes through the centre, it must have a longer portion coloured red than one passing through near the edge. In such a case, of course, every thread between these two must have this particular coloured space of a different length. Since the parti-coloured threads are formed into loops, whatever tinted portion of a thread comes in for the breadth of a flower or other figure, it must be four times as long in the yarn as it will afterwards appear in the web. Much care and correctness are therefore required in calculating the various sizes of these coloured spaces, and great nicety is likewise necessary in adjusting the pattern in the warp, because such carpets are woven on simple looms with none of the usual arrangements for figure-weaving. Mr. Whytock's first plan of colouring the yarns was by winding them on a large hollow drum, and printing each colour with a long block; subsequently small rollers, each working in its own colour box, and so arranged as to work across the drum, have been used to print the dyes. When the printing is completed, the drum appears covered with stripes or bars of different widths and tints, and the yarns are afterwards steamed to fix the colours. Mr. A. Whytock, in a paper read before the Society of Arts in 1856, thus speaks of his relative's invention:—" Not only is the Jacquard superseded, and the large frames done away with, but it is

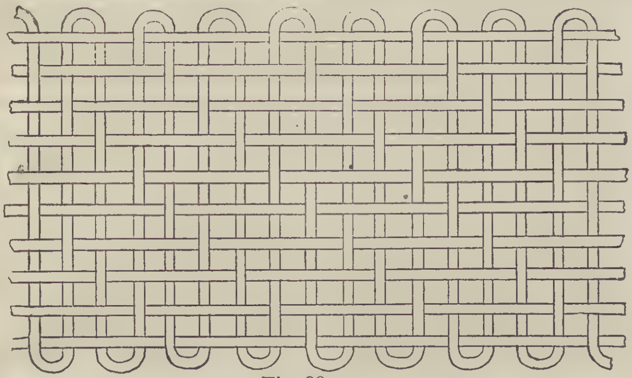


Fig. 39.

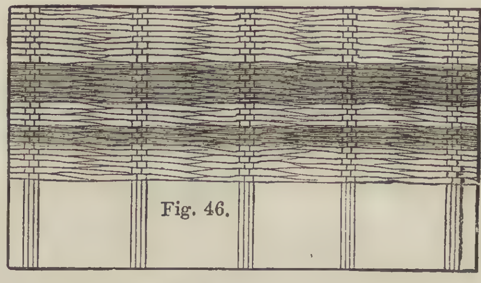


Fig. 46.

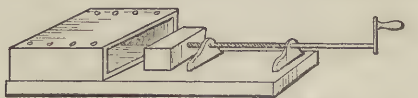


Fig. 51.

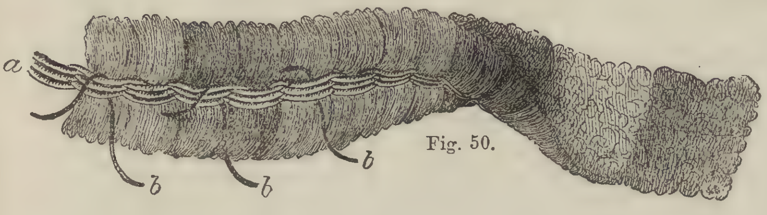


Fig. 50.

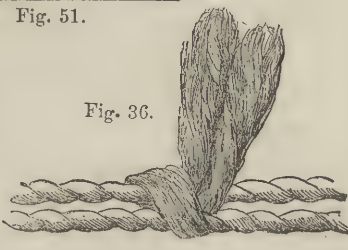


Fig. 36.

Fig. 40.

Fig. 38.

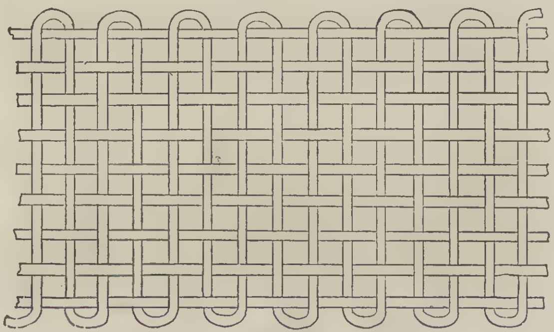


Fig. 37.

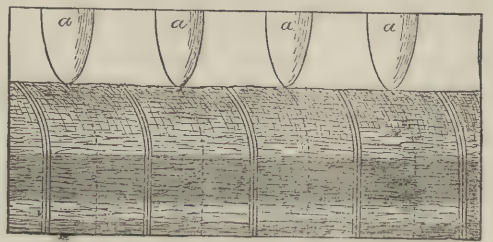


Fig. 47.

Fig. 45.

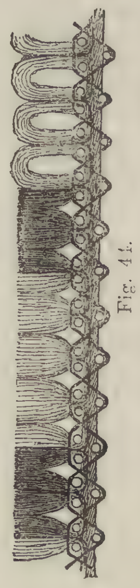


Fig. 44.

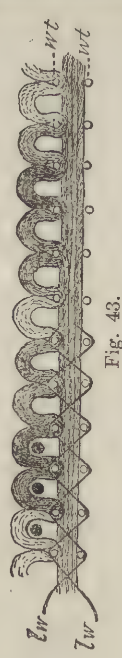


Fig. 43.

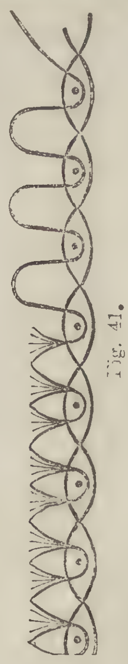


Fig. 41.

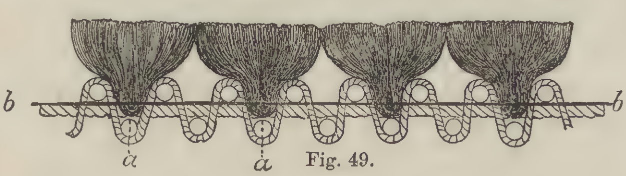
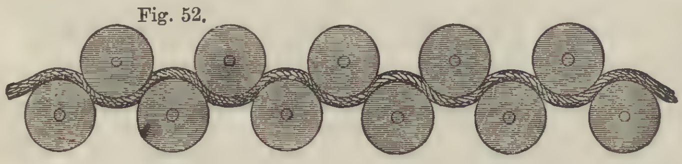


Fig. 49.

Fig. 52.



possible to place three looms to be occupied by this new fabric into the space which one Brussels loom requires. One beam is substituted for 1,300 little beams or bobbins, and a better cover is made with 780 threads than with 2,600."

Whytock's patent has been, and still is, worked on a most extensive scale in Messrs. Crossley's great establishment at Halifax, the firm having from time to time introduced great improvements in the method of printing the yarn. Probably this kind of carpet is much more largely made than any other, as it has as good an appearance as a Brussels at about two-thirds the price. But if the question were asked, is the one as economical as the other, we are afraid the answer must be "no." If we compare the structure of the two fabrics, we shall find that in the Brussels the coloured wools make up the bulk of the carpet, while in the "tapestry" the wool, although disposed in the best way to resist wear, is yet all on the surface, coarse flax or jute threads taking the place of the hidden worsted ones in the Brussels carpet. As jute, flax, or hemp has less elasticity than wool, the "tapestry" must so far fail in comfort, and experience has proved it to be somewhat wanting in durability wherever it is exposed to much wear. But as even jute carpets, costing less than a third of the price of "tapestry," are not to be despised, so, if the beautiful tapestry carpets are not all we could wish, they still suit many purposes abundantly well, and their manufacture is one of the successes of our day.

Patent Axminster Carpet.—We come now to another improvement in carpet-making, equally ingenious, and perhaps equally successful, with Mr. Whytock's, except that the fact of its being a much more costly fabric must necessarily limit its sale. It is the invention of Mr. James Templeton, of Glasgow, and is thus described in his own words in an interesting communication to Sir M. Digby Wyatt:—

"I was a shawl manufacturer in Paisley, and, amongst other goods, made a great many of what are termed chenille shawls, the process of which was to weave a pattern on a warp, the warp having been spaced on the reed according to the depth or thickness of pile required. This first cloth was then cut between the spaces into shreds, and then these shreds, having been twisted into a spiral form, were woven on to another warp, marks for the weaver's guidance having been woven in the first weaving to enable him to place the shreds so as to bring out the complete pattern in the second weaving. The idea occurred to us (one of my weavers and myself) that, if cloth could be so woven, as when cut into shreds and not twisted to form chenille, but left free, so that the two cut edges of the shred might collapse and form a pile, or fur, as we term it, it would, when re-woven on to another warp or surface, produce a velvet, a pile, or an Axminster surface. This was accomplished by a certain mode of gauze-weaving, and a patent was taken out for it. In protecting this patent, in 1847, on a trial in which we got a verdict on all the issues, the judge (the late Lord Robertson), when re-examining a witness, smartly remarked, after he had seen the difference between our products and those of our opponents (our opponents wished to make out that ours was only the old chenille process), 'Oh! I see, this new fabric (or shred) has its backbone where it ought to be, and the chenille has its backbone in its middle.'"

The first part of Mr. Templeton's process, and what really constitutes the gist of his original patent, dated 1839, consists in weaving on a separate loom a single or parti-coloured chenille of such a peculiar kind that, when cut up into strips, the lateral fibres of both cut edges are all brought up in close compact with each other. Fig. 46 shows a piece of the chenille uncut, and Fig. 47 shows the manner of cutting it, *a*, *a*, *a*, *a* being the cutting-blades. These sever the different rows as the web passes over a cylinder. Figs. 46 and 47 are taken from the reports of the Exhibition of 1871, and are on a less scale than the three following ones. A face-view of part of four rows of this chenille, or fur, or pile, as it is variously called, is given in the lower portion of Fig. 48. A cross-section of these four is seen in Fig. 49, and another view of a detached piece, showing part of the "back-bone," is given in Fig. 50. These figures, as in the case of the Brussels carpet, are double the actual size of the parts they represent of an ordinary patent Axminster, but, of course, the length of the pile varies. In the second part of the process, this chenille is woven as weft into a groundwork of flax, hemp, or jute, which forms a closely woven under-fabric, not unlike the usual basis of the tapestry carpet already noticed. Figs. 48 and 49 will show clearly enough how this is done. The upper portion of Fig. 48 represents all the threads of the fabric with the chenille removed. The "back-bone" of the chenille, which in the specimen before us is composed of several strong cotton threads crossed over each other as in gauze-weaving, so as effectually to hold in the tufts, is indicated by the strong black lines *a*, *a*, *a*. Other bold black lines at right angles to these, marked *b*, *b*, *b*, show the position of what Mr. Templeton calls the "catcher-warps," or those which are put in to hold down the chenille by its "back-bone." In Fig. 49 these parts of the texture are indicated by the same letters. The remaining warp and weft threads in the figures are those concerned in the structure of the strong under-fabric. In this kind of carpet, the elements of the design or pattern exist in the chenille, which somewhat resembles the parti-coloured yarn in the tapestry carpet, only being already in tufts it does not require the extra length to provide for loops. Indeed, Mr. Templeton took out a later patent for printing the chenille and also weft yarn of various colours in a different way from Whytock's process, but which secured the same result. He also patented a method of making his "patent Axminster" carpets with a chenille warp instead of a chenille weft, and they are sometimes constructed on this latter plan.

Templeton's carpets are frequently woven all in one piece, so that occasionally the looms are more than thirty feet wide between the frames. This style of carpet, which is variously called patent Axminster, Scoto-Turkey, and Chenille, is, from the length and fulness of the firmly-bound tufts, very durable. Fair ordinary qualities of narrow widths are only about one-fourth more in value than a good Brussels, but those made in one piece, if of fine material and intricate design, are often costly, though still less so than a hand-made Axminster. Sometimes only one carpet of a particular design is made, in which case its ownership is not unfrequently marked by armorial ensigns or monograms.

Sir M. Digby Wyatt, in his report on the carpets exhibited in Paris in 1867, says, that "the four great tests of excellence in both Brussels and pile carpeting are—first, the length of loop, or pile; second, the quality of the woollen yarns; third, the number of threads to the inch in width; and fourth, the compactness of weaving at the back, so as to perfectly tie in the loops and cut filaments which form the pile. If the pile, or tufts, can be made perfectly secure from pulling out in wear, the longer they are, or rather the higher they rise from the back of the carpet, the greater will its durability be. It is much easier to tie in 'moquettes,' or little tufts of wool plaited in by hand securely (because the threads of the tuft are already intertwisted and matted together before tying), than any loop or tuft formed from wool or worsted which has been spun, or has once been brought into a state of even moderate tension; since the latter operation injures the natural tendency of the fibre to interlock. That is why the hand-worked Turkish and Indian goods are so extraordinarily durable.

Mosaic Carpets.—Some years ago Messrs. Crossley of Halifax held a patent for what was called mosaic work in wool, suitable for carpets, rugs, screens, and like articles. It is understood that, for carpets at any rate, this kind of manufacture has now ceased; but as the process, from the unlimited use of colour which it admits of, as well as from its ingenuity, is very suggestive, we shall notice it briefly here. Real mosaic work is made by using small coloured glass rods of an infinite number of shades, from any suitable one of which the artist breaks off a bit and sticks it into a base of cement, and he thus works on, breaking and sticking in another bit, and so with all his selection of tints till his picture is completed. Now, if instead of breaking off pieces, suppose he formed his picture with the ends of the rods, leaving them entire, and they were, say, ten feet long. Here, by the use of any binding-frame, we should have a picture the same as before, but instead of the coloured glass being only a fraction of an inch, it would be ten feet thick. In this way we might have more than a hundred copies of the picture, provided it were practicable to cut across the pile of glass rods, which it is not. This is exactly the plan on which the so-called "mosaic carpet" is made, only wool is used instead of glass. Frames of wire-gauze or canvas are placed at a convenient distance apart, and between these the coloured worsteds are stretched, the picture or pattern being formed by their ends. When the

pattern is made up, it is placed in a case with movable sides and open at both ends, with a solid piston attached to it, as in Fig. 51. A solution of some adhesive cement is then applied to the fibres at one end; a length equal to the required depth of pile is next forced out of the case and cut across with a knife; and finally this is cemented to a backing of rough canvas. As many as 500 copies of a picture or pattern can thus be obtained, and many strikingly beautiful objects have been made in this way.

Felt Carpeting.—Woollen goods made entirely by the felting process are worth more attention than they appear to receive. We have already described how cloth, which is first woven, is felted; and with fabrics which are not previously woven the process is, of course, in principle the same, although the construction of some of the machinery employed is different. The art of making carpets and other felt cloths has been long practised in India and other parts of the world; indeed, it is not very new in England, but as much has been done of late years by our manufacturers to improve this class of fabrics, we might expect greater results from a process in which nature meets art half way. Carpets and similar woollen goods with wholly felted textures are made in the following way, but we do not here include felt hats:—The wool is first sorted for the different qualities of fabrics, and then carded into a thin broad lap or sliver on a carding-engine of the same kind as that used in the woollen cloth manufacture. This lap, which is so thin that it will hardly hang together, is immediately passed over a series of rollers so arranged as to fold it into a number of layers. The laps or slivers are as broad as the carding-engine will prepare, and the number of layers of these thin fleeces thus folded on the top of each other varies according to the thickness of felt required. When a close and compact texture is wanted, like the felt used in polishing plate glass, for example, what will in the end be compressed into the thickness of less than half an inch, may in this loose pile of carded layers require to be a foot thick. If it is requisite in the manufacture of ordinary woollen cloth so to prepare the wool that the filaments may be as free as possible for the felting process, this must of course be all the more necessary in the case of a fabric whose strength entirely depends on the completeness with which the fibres are held together by the minute serrations and waved structure of the wool. Hence the necessity of opening up all irregularly matted portions of the fleece by the teeth of carding cylinders, and of subsequently curling up the filaments by heat and moisture through the application of steam. The more hooking and interlocking of fibre with fibre the better, provided it is uniformly done all through the texture. After a proper thickness of carded sliver is made up it is passed through a series of rollers arranged as in Fig. 52, and which have a vibrating or lateral motion as well as a revolving motion. When subjected long enough to the rubbing action of these rollers, along with which steam is used, the felt is placed for a time in the fulling stocks, and then taken to the drying-house, where it is passed over another arrangement of rollers in an atmosphere kept at a high temperature by steam. Methods are in use for raising and cropping the surface of such felt fabrics as require it similar to those already described for thus treating woollen cloth.

Nothing more is necessary in finishing plain felt cloths, and such as are intended to receive a colour or pattern are dyed or printed. Carpets and table-covers are usually printed, but other felt fabrics, as slipper cloths, are dyed of one colour, and of these very large quantities have been made. By this process such articles as petticoats are now manufactured without a single seam or thread of yarn. All carefully-made felt goods look well, and it is asserted by those who know best, that they are not wanting in durability. We may hope, then, that both the public and manufacturers may yet derive more benefit than hitherto from a class of fabrics, composed no doubt of a material comparatively expensive, but at the same time made by a process than which nothing much simpler could be imagined.

With this we bring our papers on "Wool and its Industrial Applications" to an end, having traced all the phases of treatment necessary to convert this useful material into the numerous fabrics of every-day use of which it forms either the whole or a part, from the first cleansing that it receives when fresh from the sheep's back to the final touches which finish its conversion into a valuable article of merchandise.

THE LATHE.—XX.

By Henry Northcott.

PLANING AND SHAPING APPARATUS APPLIED TO THE AMATEUR MECHANIC'S LATHE.

The lathes described in the last chapter are equal to the production of any kind of plain turned work in metals or wood, such as cylindrical turning for shafts, spindles, and bolts; surface-turning of face-plates, discs, collars, and cylinder covers; and angular and taper turning for circular slides, cones, tapering shafts, and connecting-rods. Any kind of hand-tool work may also be executed in them, as well as screws and spirals of any usual pitch. But these capabilities, extensive though they be, are insufficient for all the amateur's requirements. It is necessary for him that the lathe, in addition to its ordinary uses, should be able to aid in the execution of work other than turned, and Fig. 128 will show how the amateur mechanic is enabled to plane up a piece of metal by means of a planing apparatus applied to the lathe.

The lathe to which the planing mechanism is applied is a simple hand-tool lathe, as made by Mr. Munro; it has a slide-rest, shown on the ground; but this is not used at the same time as the planer. The planing machine when it is not required is removed from the bed, which is then kept clear for the usual lathe work. When in use, however, it is placed upon the bed in the position shown in the engraving. It is as well to make a couple of marks—or one will suffice—on the edge of the bed to indicate the proper place for the bed-plate of the machine, as one portion works in connection with the mechanism on the end of the lathe-bed, from which it should stand at a certain distance. The machine consists of a massive bed-plate carrying two upright standards, across which is placed a slide termed the cross-slide, and upon this is placed the tool-box or sliding tool-holder. The upper part of the machine-bed is fitted with V-grooves to convert it into a slide for the sliding table shown upon it, and which is made larger than the machine-bed. It will be understood that the machine-bed is fixed to the lathe-bed, and has no motion whatever, but the table is connected at the back, by means of a strong connecting-rod, with a crank-arm attached to a horizontal disc having a vertical spindle. The vertical shaft is driven from the crank-shaft of the lathe by a pair of bevel wheels, that one on the crank-shaft being about half the size of the wheel on the vertical shaft, so that the lathe rotates only half as fast as the former. The crank-shaft may be run from 50 to 80 revolutions per minute, the other will consequently make from 25 to 40, and the sliding table makes the same number of strokes. A parallel vice is shown, fastened down upon the sliding table, with a rough casting held between its jaws ready for planing up to form a portion of some slide-rest. The vice may, however, be removed, and the work fastened directly to the slide-table when the shape of the article is such as to render the latter plan more convenient. The work, it will be understood, travels under the cutting-tool, which, with the exception of its side-feeding motion, is held stationary. The stroke of the planing-table is made such that the work may travel a sufficient distance past the tool at each end to allow the tool to clear itself from its cut and feed-traverse taken for another. In order to allow the travel of the slide to be thus adjusted, the crank-arm is necessarily made so that its "throw" may be varied from nothing up to the full range of the machine-slide; and the point at which the rod connects the crank with the table is made movable, to allow of the limits of the strokes to be adjusted in relation to the tool. Or this latter adjustment may be effected by moving the machine-bed upon the lathe-bed.

The tool-holder may be moved the whole length of the cross-slide, and this movement gives the feed-traverse for the horizontal cuts; an upright slide is provided for the vertical cuts, and the same slide takes the angular cuts, when it is swung round upon a central pin which fastens it to the slide-plate. The tool-box encloses the tool, and it is fitted with two trunnions, which allow the tool to have a slight movement forward during the return stroke of the work, by which means the tool is withdrawn somewhat from contact with its cut, and its breakage from the friction rendered less likely. When the lathe, to which a planing apparatus is to be applied, has a slide-rest to it, it is advisable to make the tool-holder of the planing-machine the proper size for receiving the slide-rest tools, in order that one set of tools may answer for both turning and planing. The cross-slide may be

moved anywhere up and down upon the two uprights carrying it, by turning round the small winch-handle, shown at the top left-hand corner of the engraving; this motion drives two upright screws through two pairs of bevel pinions on the tops of the standards, and the screws work through two nuts fixed to the cross-slide. If a thin plate had to be planed, and it was fastened directly to the sliding-table, the cross-slide would have to be lowered to bring the tool down within working reach of the surface to be planed; but if a bulky article were fastened to the table, the cross-slide might require raising to let the work pass under the tool. The traverse for the vertical and angular cuts is got by hand, but the movement of the tool along the cross-slide is made self-acting by the levers shown at the side. These, actuated in the first place by a tappet adjusted to the sliding-bed, move round the traverse-screw of the cross-slide by a ratchet-wheel and click, and one or more teeth of the ratchet are taken by altering the throw of the lever according as a fine or coarse traverse is required. When this apparatus is to be used, the lathe-bed is cleared of the slide-rest and screw-poppet, the machine placed on the lathe and bolted down in place, the work fixed to the sliding-table either by being held in the vice or otherwise, a sharp tool placed in the tool-box, the height of the cross-slide adjusted to bring the tool within reach of the work, the crank-arm set to give the sliding-table a stroke rather longer than the cut, and the connection of the connecting-rod with the table arranged to bring the stroke in proper place under the tool. The treadle is then worked to drive the crank-shaft in either direction, whilst the tool is set into cut by moving the screw of the vertical or other slide. The contrivance is very efficient so far as its working goes, but its great weight is somewhat inconvenient. Fig. 129 shows a very neat apparatus for a somewhat similar purpose, and of which Messrs. Booth Brothers, of Dublin, are the manufacturers. It is termed a shaping machine, and is shown applied to one of their four-inch centre amateur's lathes, upon the bed of which it is bolted when required for use in the position shown, and with its left-hand driving disc engaged by the driving-pin of the lathe. The machine is capable of "shaping" (shaping is a technical term generally used for planing on a small scale) a surface 7 inches long and 3 inches wide at one setting; that is, the maximum stroke of the tool is 3 inches, and the traverse of the slide and work is 7 inches. The instrument is self-contained, and when bolted to the lathe-bed is ready for work. The motive power for driving it is obtained from the lathe-spindle, the driving-pin of which engages into a space cut in the machine driving-plate, and this connection allows the motion to be communicated without the necessity of the spindles of the two being perfectly in line, although of course they should be placed so. At the other end of the same spindle as the driving-plate there is a crank-plate with adjustable crank-pin, but the crank-pin, instead of being connected direct to the slide, is arranged to slide up and down a slotted arm, a square slide block being, however, interposed between the crank-pin and slot to increase the wearing surface. The slotted arm is fixed below upon a stud attached to the main casting or bed-plate of the machine, and the motion of the crank-pin up and down in the slot causes the arm to oscillate around this stud or fulcrum. But its motion has a varying angular velocity, which becomes greater as the crank-pin arrives at that end of the slot nearest the fulcrum, and less as it approaches the other. In this apparatus the tool moves backwards and forwards over the work in order to give the cutting stroke, whilst the work only moves sideways to give the traverse between the cuts. The slide carrying the shaping head and slide works in V's formed in the main casting, which is stationary. It receives its stroke from the slotted arm by a strong connecting-rod jointed to the middle of the slot, and at its other end to the slide by a pin which is susceptible of a horizontal adjustment. As the slot-arm oscillates it gives a reciprocating motion to the shaping slide, but owing to the varying angular velocity of the former, the slide moves forward slowly and returns faster, so that the cutting stroke is performed in a certain time and the return or idle stroke in less. The tool-slide is attached to the front of the shaping head, and is actuated by hand; this is the slide used for setting in the tool for horizontal cuts, and for the traverse of vertical and angular cuts. It is shown set for an angular cut. The tool-box is of the same form as in the last case, and a tool is shown in its place. The front of the main casting projects out over the lathe-bed,

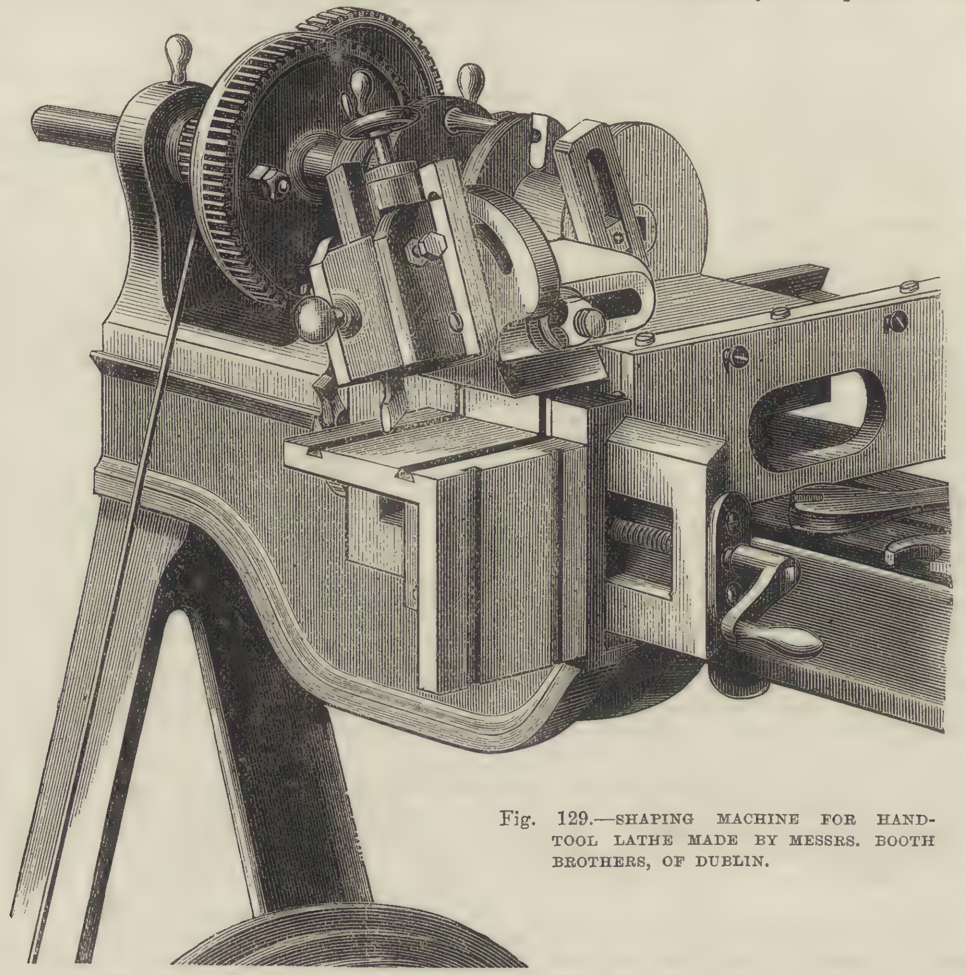
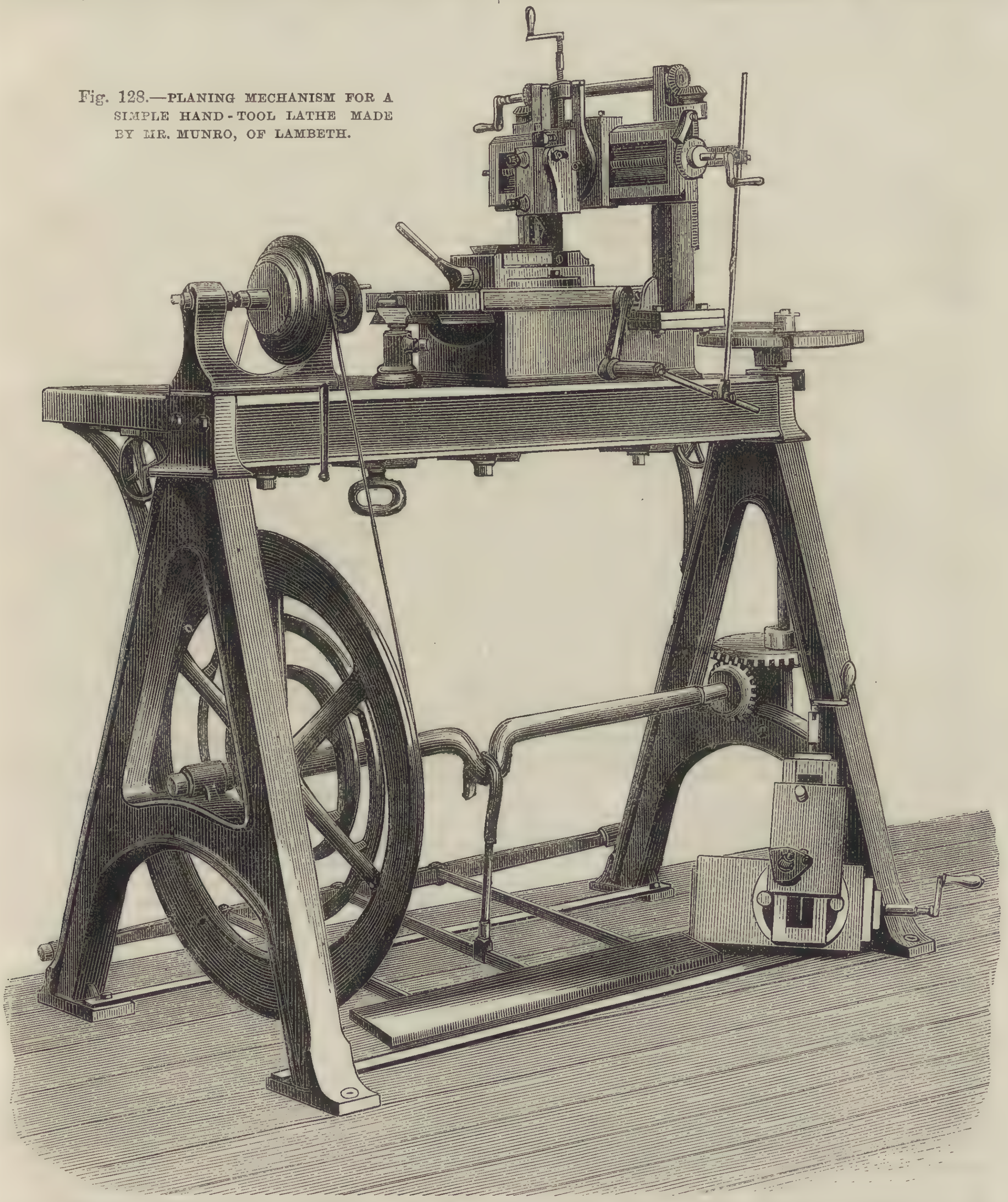


Fig. 129.—SHAPING MACHINE FOR HAND-TOOL LATHE MADE BY MESSRS. BOOTH BROTHERS, OF DUBLIN.

where it is formed into a horizontal slide furnished with a screw and winch-handle, and to the moving part of the slide is bolted an angular table to which the work is affixed. Automatic motion is given to the work by means of the mechanism seen on the left of the machine, and which consists of a ratchet and click upon the traverse-screw, actuated by a cam-groove cut in the reverse side of the crank-plate.

When the machine is wanted for use, it is placed in position on the bed, the work to be planed is attached to the angular table by a vice or otherwise, the table is raised or lowered to bring the work within cutting reach of the tool, the length and position of the stroke is adjusted, and the tool is then brought into cut. Altogether, this is one of the neatest little shaping machines I have met with. The slotted arm for the quick return of the tool is frequently used in larger machines, but Messrs. Booth Brothers have worked the whole out on this small scale in a very creditable manner, and the result is an efficient tool for the amateur's use.

Fig. 128.—PLANING MECHANISM FOR A SIMPLE HAND-TOOL LATHE MADE BY MR. MUNRO, OF LAMBETH.



The space at my disposal will not admit of any reference to ornamental or fancy turning, which, however, although a very interesting and pleasing branch of the art, is not of the same industrial importance as the branches treated of.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XL.—THE EARL OF ROSSE, K.P., F.R.S.—GREAT REFLECTING TELESCOPES.

THE applicability of the remark of Sir Humphry Davy—that "our aristocracy may be searched in vain for philosophers"—is strikingly disproved in the genius with which an Irish nobleman has, within the last half century, constructed telescopes far exceeding in magnitude and power all previous instruments of its class. The originator and architect of these magnificent instruments, the construction of which we are about to describe, had long been distinguished in scientific research as Lord Oxmantown, and may be considered to have gracefully commemorated his succession to the earldom of Rosse, and his presidency of the Royal Society, by the completion of the marvellous work with which his name will be hereafter indissolubly associated.

Sir David Brewster has felicitously observed that "the long interval of half a century seems to be the period of hybernation during which the telescopic mind rests from its labours in order to acquire strength for some great achievement. Fifty years elapsed between the dwarf telescope of Newton and the large instruments of Hadley; other fifty years rolled on before Sir William Herschel constructed his magnificent telescope; and fifty years more passed away before the Earl of Rosse produced that colossal instrument which has already achieved such brilliant discoveries." ("Life of Sir Isaac Newton," vol. i., p. 62.) Dr. Robinson has eloquently expressed his delight that "so high a problem as the construction of a six-feet speculum should have been mastered by one of his countrymen—by one whose attainments are an honour to his rank, an example to his equals, and an instance of the perfect compatibility of the highest intellectual pursuits with the most perfect discharge of the duties of domestic and social life."

The Earl of Rosse, the eldest son of the second earl, was born at York, June 17, 1800, and entered the University of Dublin in 1818, whence he passed, in 1819, into residence at Magdalen College, Oxford. He early distinguished himself by his fondness for mathematical studies; and he took his degree of B.A. in 1822 as a first class in mathematical honours. Whilst bearing the courtesy title of Lord Oxmantown, he sat as M.P. for King's County from 1821 till the end of the first Reformed Parliament, when he retired from political life for the purpose of devoting himself more completely to philosophical pursuits. In 1841 he succeeded to the peerage, but as his Irish coronet did not give him a seat in the House of Lords, he was still enabled to follow his tastes and inclinations until February, 1845, when he was elected one of the representative peers for Ireland, an office which is always held for life.

To the improvement of the reflecting telescope, by increasing its magnifying power and light by the construction of as large a mirror as possible, Lord Rosse directed his attention as early as 1828, his operations being carried on at his seat at Birr Castle, Parsonstown, about fifty miles west of Dublin. His lordship has been described as fitted for his work by a rare combination of "talent to devise, patience to bear disappointment, perseverance, profound mathematical knowledge, mechanical skill, and uninterrupted leisure from other pursuits" (Dr. Thomas Woods). Lord Rosse has been further characterised as "the great mechanic of the age, a man who, if he had not been born to a peerage, would probably have taken the highest rank as an inventor. So thorough is his knowledge of smiths' work that he is said to have been pressed, on one occasion, to accept the foremanship of a large workshop by a manufacturer to whom his rank was unknown." Like Sir William Herschel, he employed common workmen in his great works. Mr. Weld, in his excellent account of the telescope, says, "All the workmen are Irish; they were trained under the superintendence of Lord Rosse, being taken from common hedge schools, and selected in consequence of their giving evidence of mechanical skill. The foreman, a man of great intelligence, is of similar origin; and Lord Rosse assured me such was his skill that, during his lordship's absence, he felt confident that his foreman could construct a telescope with a six-feet speculum similar in all respects to that now erected."

Machinery was found necessary to grind and polish large specula, and Lord Rosse constructed and used for the purpose a steam-engine of two-horse power. He first ground and polished specula 15 inches, 2 feet and 3 feet in diameter. He next ascertained the most useful combination of metals for specula, in whiteness, porosity, and hardness, to be copper and tin. Of this compound the reflector was cast in pieces which were fixed on a bed of zinc and copper, a species of brass which expanded by heat in the same degree as the pieces of the speculum themselves. They were ground as one body to a true surface, and then polished by machinery moved by the steam-engine. Its mechanism was entirely of Lord Rosse's invention, and the result of close calculation and observation. It consisted chiefly in placing the speculum with the face upward, regulating the temperature by having it immersed in water, usually at 55° Fahr., and regulating the pressure and velocity. This was found to work a spherical figure in large surfaces with a degree of precision unattainable by hand, the workman, by working above and upon the face of the speculum, being able to examine the operation as it proceeded without removing the speculum, which, when a ton weight, is no easy matter.

"The contrivance for doing this is very beautiful. The machine is placed in a room at the bottom of a high tower, in the successive floors of which trap-doors can be opened. A mast is elevated on the top of the tower, so that its summit is about 90 feet above the speculum. A dial-plate is attached to the top of the mast, and a small plane speculum and eye-piece, with proper adjustments, are so placed that the combination becomes a Newtonian telescope, and the dial-plate the object.

"The last and most important part of the process of working the speculum is to give it *a true parabolic figure*—that is, such a figure that each portion of it should reflect the incident rays to the same focus. Lord Rosse's operations for this purpose consist—1st, of a stroke of the first excentric, which carries the polisher along *one-third* of the diameter of the speculum; 2nd, a trans-stroke twenty-one times slower, and equal to 0·27 of the same diameter measured on the edge of the tank, or 1·7 beyond the centre of the polisher; 3rd, a rotation of the speculum performed in the same time as thirty-seven of the first strokes; and 4th, a rotation of the polisher in the same direction about sixteen times slower. If these rules are attended to, the machine will give the true parabolic figure of the speculum, whether it be 6 inches or 3 feet in diameter. In the three-feet speculum the figure is so true with the whole aperture that it is thrown out of focus by a motion of less than the *thirtieth of an inch;* and even with a single lens of one-eighth of an inch focus, giving a power of 2,592, the dots on a watch-dial are still in some degree defined."

Thus was executed the three-feet speculum for the twenty-seven feet telescope placed on the lawn at Parsonstown, which, in 1840, showed with powers up to 1,000, and even 1,600; and which resolved nebulæ into stars, and destroyed that symmetry of form in globular nebulæ upon which was founded the hypothesis of the gradual condensation of nebulous matter into suns and planets. The instrument also discovered in the moon a mountainous tract near Ptolemy, every ridge of which is dotted with extremely minute craters, and two black parallel stripes in the bottom of Aristarchus. Dr. Robinson, in his address to the British Association in 1843, stated that in this telescope a building the size of the court-house at Cork would be easily visible on the lunar surface.

Lord Rosse now resolved to attempt, by the same processes, the construction of another reflector with a speculum 6 feet in diameter and 56 feet long. The focal length of the speculum is 54 feet. It weighs four tons, and, with its supports, is seven times as heavy as the four-feet speculum of Sir William Herschel. The speculum is placed in one of the sides of a cubical wooden box, about eight feet wide, and to the opposite end of this box is fastened the tube, which is made of deal staves an inch thick, hooped with iron clamp-rings, like a huge cask. It carries at its upper end, and in the axis of the tube, a small oval speculum, six inches in its lesser diameter. Dr. Peacock, Dean of Ely, walked through the tube with an umbrella up! The tube, by its exquisitely adjusted machinery, is moved with all the ease and precision of a microscope. The telescope is established between two lofty castellated piers 60 feet high, and is raised to different altitudes by a strong chain-cable attached to the top of the tube. This cable passes over a pulley on a frame down to a windlass on the ground, which is wrought by two assistants. The telescope is balanced by counter-weights suspended by chains, which are fixed to the sides of the tube,

and pass over large iron pulleys. The immense mass of matter weighs about twelve tons.

On the eastern pier is a strong semicircle of cast iron, with which the telescope is connected by a rack-bar with friction rollers attached to the tube by wheel-work; so that by means of a handle near the eye-piece, the observer can move the telescope along the bar on either side of the meridian to the distance of an hour for an equatorial star.

On the western pier are stairs and galleries. The observing gallery is moved along a railway by means of wheels and a winch; and the mechanism for raising the galleries to various altitudes is very ingenious. Sometimes the galleries, filled with observers, are suspended midway between the two piers over a chasm sixty feet deep.

The speculum was cast on the 13th of April, 1842; ground in 1843; polished in 1844; and in February, 1845, the telescope was ready to be tried. The speculum was polished in six hours, in the same time as a small speculum; and no particular care was taken in preparing the polisher. The casting of a speculum of nearly four tons was an object of great interest. To ensure uniformity of metal, the blocks from the first melting, which was effected in three furnaces, were broken up, and the pieces from each of the furnaces were placed in three separate casks, A, B, and C; then, in charging the crucibles for the final melting of the speculum, successive portions from cask A were put into furnaces *a*, *b*, *c*; from B into *b*, *c*, *a*; and so on. To prevent the metal from bending or changing its form, by reason of its weight, Lord Rosse made the speculum rest upon a surface of pieces of cast iron, strongly framed, and carrying levers to give lateral support; it is attached to an immense joint, like that of a pair of compasses moving round a pin, in order to give the transverse motion for following the star in right ascension. This pin is fixed in the centre-piece between two trunnions, like those of an enormous mortar, lying east and west, and upon which the telescope has its motion in altitude.

The impression made by the enormous light of the telescope (says the Astronomer Royal, Sir G. B. Airy) is partly by the modifications produced in the appearance of nebulæ already figured, partly by the great number of stars seen at a distance from the Milky Way, and partly from the prodigious brilliancy of Saturn. The account given by another astronomer of the appearance of Jupiter was that it resembled a coach-lamp in the telescope; and this well expresses the blaze of light seen in the Rosse instrument. By its means the flat bottom of the crater in the moon called Albategnius is distinctly seen to be strewed with blocks not visible with less powerful instruments; while the exterior of another (Aristillus) is intersected with deep gulleys radiating from its centre.

Sir David Brewster thus eloquently sketches the powers of this stupendous telescope:—"We have, in the mornings, walked again and again, and ever with new delight, along its mystic tube; and at midnight, with its distinguished architect, pondered over the marvellous sights which it discloses—the satellites, and belts, and rings of Saturn—the old and new ring which is advancing, with its crest of waters, to the body of the planet—the rocks, and mountains, and valleys, and extinct volcanoes of the moon—the crescent of Venus, with its mountainous outline—the systems of double and triple stars—the nebulæ and starry clusters of every variety of shape—and those spiral nebular formations which baffle human comprehension, and constitute the greatest achievement in modern discovery."

Sir David Brewster gives the effective magnitude of this colossal telescope compared with other instruments in the following table, which contains the number of square inches in each speculum, on the supposition that they were square in place of round:—

Names of Makers.	*Diameter of Speculum.*	*Area of Surface.*	*Names of Makers.*	*Diameter of Speculum.*	*Area of Surface.*
Newton.	1 inch . .	1 sq. in.	Lassell .	2 feet .	576 sq. in.
	2·37 inches .	5·6 ,,	Lord Rosse	2 feet .	576 ,,
Hadley .	4·5 inches .	20 ,,		3 feet .	1296 ,,
	5 inches .	25 ,,	Herschel .	4 feet .	2304 ,,
Hawksbee	9 inches .	81 ,,	Lord Rosse	6 feet .	5184 ,,
Ramage .	21 inches .	441 ,,			

The Rev. Dr. Scoresby records that from the guidance we possess of the comparative power of the six-feet speculum in the penetration of space, we might fairly assume the fact, that if any other telescope now in use could follow the sun if removed to the remotest visible position, or till its light would require 10,000 years to reach us, the grand instrument at Parsonstown would follow it so far that from 20,000 to 25,000 years would be spent in the transmission of its light to the earth. But in the cases of clusters of stars, and of nebulæ exhibiting a mere speck of misty luminosity, from the combined light of perhaps hundreds of thousands of suns, the *penetration* into space, compared with the results of ordinary vision, must be enormous; so that it would not be difficult to show the *probability* that a million of years, in flight of light, would be requisite, in regard to the most distant, to traverse the interval.

Lord Rosse assures us that every object on the surface of the moon 100 feet high is distinctly visible, and under favourable circumstances even objects sixty feet in height. Rocks and stones innumerable are seen; but *no architecture, no buildings*, although such a structure as Somerset House, for instance, ought to be distinctly visible, far less a street, a village, or a town. Not a vestige of green fields, or of water, appears; although even a small reservoir, or a not very large patch of green, would be recognisable: all seems desolate. There is something awful in such a desert solitude. But the earth, too, has its desert wastes. Can it be, that what we do see of the lunar surface is but its desert districts, while what we do not see is not unlike the face of our own planet elsewhere than in its solitary districts? There is an ingenious theory of the moon consistent with such an idea; and we cannot see how the quibbling question of the lunar rotation can subvert the inferences and conclusions based upon that theory. Let us suppose that the lunar form is that which would naturally arise from the operation of the centrifugal force on a (once?) fluid sphere revolving, and say even rotating, round its primary, so as always to present the same phase towards the primary, that is, towards the centrifugal centre. Would not the fluid mass of the sphere so revolving and rotating be centrifugalised out of the strictly spherical form, and become oblate with its greatest diameter in the line of the radius uniting it with its primary? And if there existed even a fluid ocean and an atmosphere on the surface of such a sphere, would not that ocean and that atmosphere be also centrifugalised or driven outwards to the hemisphere farthest from the primary? In such a case, the base, as it might now be called, of the oblate sphere, or its hemisphere next to the primary, might well be a desert waste, without a drop of water; while the exterior hemisphere, invisible to us, might for all that be full of life.

COTTON-SPINNING.—V.

By J. Robertson.

THE MULE AND THROSTLE-FRAME.

We have now to consider one of the greatest trimuphs of mechanical art, so complex and intricate as to make each separate movement a complete study in itself, and yet perfectly reliable in its action. It is a notable instance of the success with which human ingenuity has sought to master the laws of force and matter, and render the materials with which we are surrounded subservient to our wants. To give anything like an adequate description of the self-acting mule is impossible within the limits of this paper. The multiplicity and complication of wheels and levers are so great, and their arrangement and construction are so varied by the different makers, that all we shall attempt will be to describe the general working and appearance of the machine, the principle of its more important movements, and the part each has to perform.

As has already been stated, the mule is now made to contain from seven hundred to nine hundred spindles. These are arranged, at distances varying from an inch to an inch and a half, upon the "carriage," or movable part of the mule, in one long row, which is interrupted at the middle for about thirty inches by the "headstock." Here the principal machinery is located, and from this the different movements are communicated. A beam stretches right and left from the headstock supporting the drawing-rollers. Behind this beam stand the creels which hold the bobbins of roving received from the fly-frames.

The appearance of the mule and arrangement of the more prominent parts of it will be understood by referring to Fig. 1, in which the headstock is shown with a portion of the carriage, creels, etc. Within the carriage there is a tin cylinder which, by means of small cords or bands, drives the spindles, and

along the top of the spindles stretch two wires called the "fallers," one of which guides the yarn upon the cop. Between the roller-beam and the creels the *back-shaft* extends to each end of the mule, where it is furnished with pulleys, which, by means of a cord fastened to the carriage, and passing round a fixed pulley upon the end-piece of the mule, at the extremity of the "draw," take the carriage out. This shaft is driven by the main-shaft, which is placed on the upper part of the head-stock, through a series of connecting wheels. At the end of the main-shaft there is the "rim," or fly-wheel, which drives the tin cylinder by means of an endless double band passing round carrying pulleys.

The bobbins of roving are set in the creels upon pegs made of hard wood, and having their lower extremity tapered to a fine point. These revolve upon a glazed earthenware step, so that the friction is reduced to the smallest possible degree. Were it otherwise, the slender half-spun roving would break under the strain of unwinding. From the creels the roving passes to the drawing-rollers, guided by means of steel plates with slots. Between the first and second roller there is another row of guiding plates, and both of these are moved backwards and forwards longitudinally by means of an excentric, so that the roving may not run continuously on one place, which would cause the speedy destruction of the leather clothing. The rollers are similar to those of the machines already noticed, but not quite so large, being generally about one inch in diameter. They are in three sets: the first and second merely take in the cotton, whilst the third draws it to the size required. These drawing-rollers are adjustable to suit the staple of the cotton. The speed of the first roller is fixed, and from it the other rollers are driven by means of wheels and pinions, so that by changing these the spinner is enabled to alter the size or count of the yarn. The weights are in some cases hung upon the front top roller alone, whilst the back ones press with nothing but their own weight upon the lower ones. In others, by means of saddles, the weight is distributed over all three. Upon the top of the front roller, and also underneath, there are cleaners placed for lapping up loose waste or untwisted roving. The cotton having passed the rollers, reduced to the requisite grist, is twisted by the spindles, which at the same time move slowly backwards from the beam. This movement of the carriage is slightly in excess of the circumferential velocity of the front rollers, or of the rate at which the cotton is delivered by them, and the excess is called the "gaining" of the carriage. It has for its object the prevention of looping or doubling up, which, but for this stretching, might take place in the thread. The spindles are inclined towards the rollers at such an angle as admits of the thread slipping over the top, and no winding up takes place. So soon as the carriage has receded to the end of the "draw" or "stretch" — which usually extends to about sixty inches—it stops; but the spindles still continue to revolve until the proper quantity of twist has been imparted to the yarn. They then make a few revolutions backward until the corresponding number of turns of yarn which run up to the point have been unwound. Simultaneously, the wire of the front faller comes down upon the threads, and guides them upon the spindle or cop as the carriage returns gently to the beam. Then the faller resumes its former position, and the carriage begins a new stretch. To keep the yarn at a uniform degree of tension whilst the winding on is taking place, was one of the most difficult problems to solve in the early attempts to introduce a self-acting mule. This is now admirably done by means of the "counter-faller." During the period that the carriage recedes from the beam, whilst the spinning is being done, the wire of the front faller or guide remains stationary at a short distance *above* the threads, and close by the point of

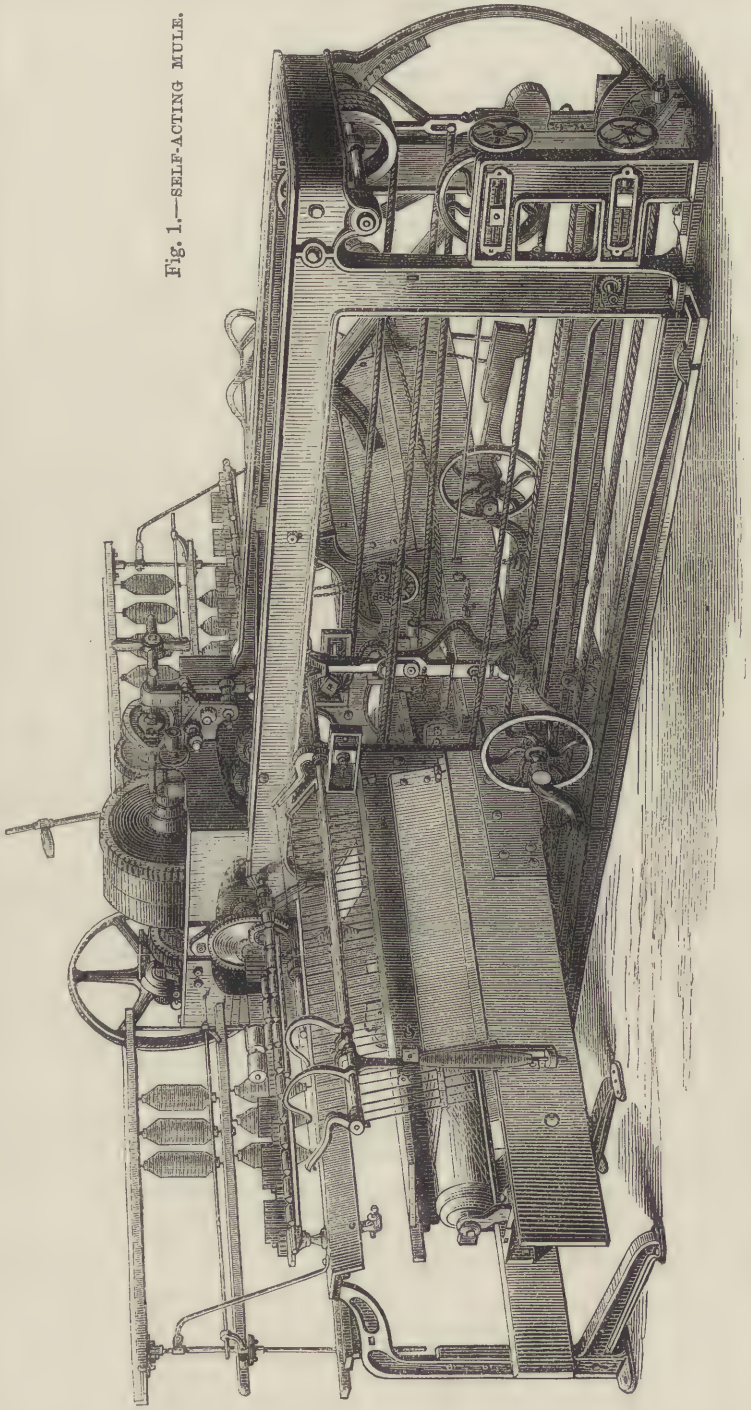


Fig. 1.—SELF-ACTING MULE.

the spindle, whilst the position of the counter-faller wire is *under* the threads, and a little further off the spindle (see Fig. 2, in which A is the front faller, and B is the counter). Both have a tendency to rise, being acted upon in the one case by a strong spiral spring, and in the other by weights; but the front faller is stopped at its proper position by a catch, whilst the other is held by a chain connecting it to the first. Now when the spinning is finished, and the front faller is depressed for the purpose of guiding the yarn upon the cop, it slackens the chain and sets the other free to rise against the yarn. To prevent the strain which would be brought upon it from the two wires striking it suddenly in opposite directions, the counter-faller is relieved of its weight by a short inclined plane fixed to the floor (C) at the end of the stretch; and only when the carriage has commenced its return movement does the weight-lever D glide off the incline and the wire bear with its full pressure on the thread. This pressure is regulated to make a firm, compact cop without unduly straining the yarn.

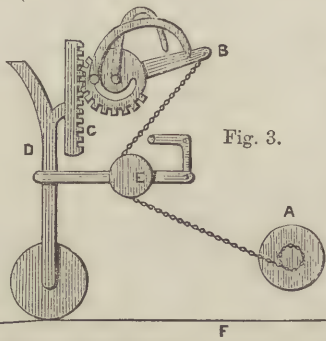


Fig. 3.

the spindles by the rim-wheel J, the main shaft drives the taking-out motion of the carriage, and also the drawing-rollers by means of a series of wheels (I) and two clutch-boxes.

When the carriage has reached the extremity of the stretch, it comes in contact with a projection upon a lever or rod, which either directly, or through a second lever or cam-shaft, disengages the clutch-boxes of the back shaft and of the rollers. At the same moment the action of a powerful spring is brought to bear upon the oscillating belt-guide, tending to throw it off the pulley which drives the spindles. This force is held in check by a small catch until the yarn has received its proper amount of twist, when the catch is lifted by a finger. Instantly the belt or strap passes on to the other pulley, and the spindles cease to revolve. A worm upon the end of the main shaft, and pinions which are calculated to give the twist for the particular yarn which is being spun, work the finger. As a rule, the quantity of twist to be given increases with the fineness of the yarn, so that

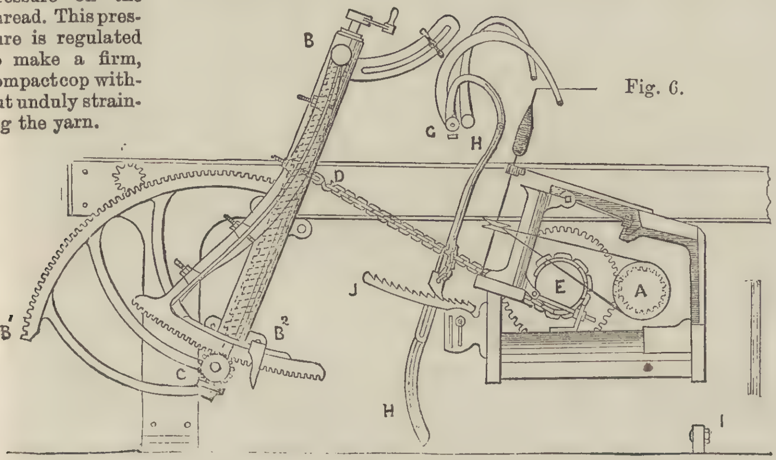


Fig. 6.

Fig. 4.

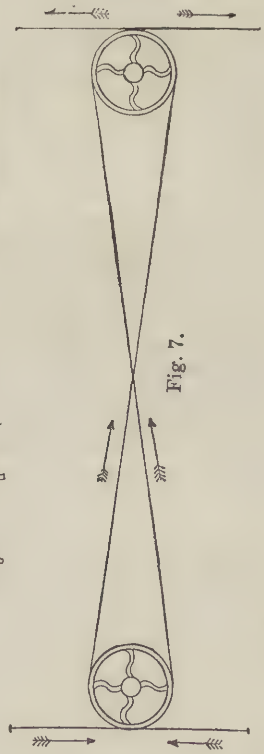


Fig. 7.

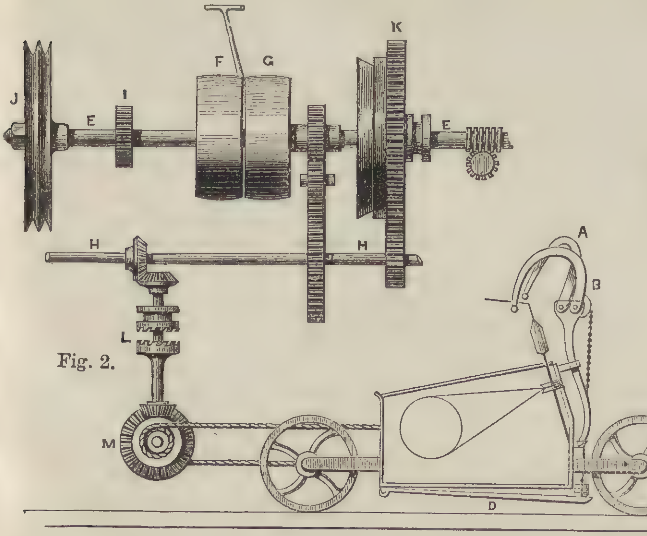


Fig. 2.

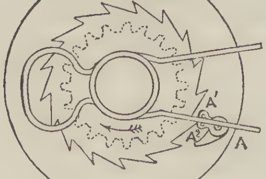


Fig. 5.

Motion is given to the spindles, as has already been said, through the main-shaft, E, placed on the upper part of the headstock. Upon this shaft there are two pulleys, one of which (F) drives it; the other (G) runs loose upon E, and communicates an independent motion to a second shaft (H). Besides driving the *twist-pinion* requires to be changed when any material alteration is made in the count of the yarn.

The driving-strap is now running upon the second pulley G. Upon the shaft underneath, which is driven by it, there are two wheels, the first driving a large friction-box (K) revolving loosely

upon the main shaft, in an opposite direction, and the other, by means of an upright shaft, driving a clutch-box (L) communicating motion to the scroll-pulley M. The same movement which has thrown the strap upon the second pulley brings the friction-box into conjunction with the corresponding friction-cone *fixed* upon the main shaft. By this means the "backing-off" motion is communicated to the spindle until the turns of thread between the cop and the point of the spindle have been unwound, when, by another piece of mechanism, which will be explained afterwards, the friction-box is set free, and the clutch-box driving the two scroll-pulleys comes into action. One of these scroll-pulleys has a rope attached to it and to the carriage, so that when motion is given to it, it winds up the rope and draws in the carriage to the beam. The object in having the pulley of a scroll, or rather of a double scroll form, is that the motion of the carriage may be gentle at first, gradually increasing as it goes in, until near the beam, when again it diminishes. The other pulley has its scroll set opposite to this, and gives out a rope at the same rate as the other takes it or winds it up. This serves as a check upon the carriage, which, by the force of inertia, might outstrip the speed which the taking-in scroll-pulley is calculated to give.

The coping or building motion is illustrated by Fig. 3. The "backing-off" motion, which has already been alluded to, as reversing the spindle just before the winding up takes place, causes the chain which is attached to the tin cylinder A to be wound upon a small barrel which is loose on it, but which is acted upon by means of a small catch-wheel when the motion of the cylinder is reversed. The winding up of the chain draws down the arm B, which is fixed upon the faller-rod, until the toothed bar C is raised up to the shoulder upon D. As the pressure of the chain is brought upon D, through the pulley E, and the bar upon which it is fixed, D yields to the pressure when C has passed the shoulder, so that C rests upon it. This movement of the upright rod D communicates through the bell-crank upon which E is fixed to the friction-box, K, and clutch, L (Fig. 2), simultaneously setting the first free and bringing the other into action. Thus the "backing-off" motion is continued always until C rests upon the shoulder of D. As the cop approaches completion, and gets near the end of the spindle, the turns of yarn which have to be unwound are always decreasing; but D, as will be seen immediately, also changes its position. D is attached to a wheel which runs with the carriage upon the coping rail, F. This rail has a vertical movement caused by the triangular plates, G. When about to commence a set of cops these plates are drawn forward by the spinner turning the handle at H, which operates by means of screws until the rail is at its highest position. This throws the guiding wire of the faller to its lowest point before it rests upon the shoulder of D. From this position the coping rail is gradually lowered as the cop increases by means of a ratchet-wheel, H, which receives a slight motion with each return of the carriage, and screws back the "shaper plates," so that the yarn is built upon the spindle in the shape required (Fig. 4). As at first there must be just sufficient movement of the faller-wire upwards upon the spindle with each successive winding as shall make an abrupt taper at the lower end of the cop, the incline upon the plates is very gradual until the bottom of the cop is formed, or until the full diameter is attained. After this the change of position of the faller is exactly the same each time until the cop is finished. The wheel which is fixed to the front faller, and which works the toothed vertical bar, has a concentric slot to allow of the counter-faller rod passing through it without interfering with its working. When the carriage has returned to the beam, and the yarn has been wound up, the upright bar D touches a carefully-set projection upon the stock-head, by which it is knocked from under the toothed bar. Immediately the fallers rise to the position they have when the carriage is receding from the beam.

We shall now consider the winding motion and the method by which the spindles are made to revolve when the carriage is returning to the beam. Revolving loose upon the shaft which connects the cylinders at the headstock, there is a wheel and disc which are geared to a barrel whose bearings are fixed upon the "square" (the strong iron plate which connects the two parts of the carriage at the headstock), and which therefore moves with the carriage. From the barrel a chain extends to the "quadrant." This chain is wound upon the barrel, as the carriage recedes from the beam, by the unwinding of a cord which has a weight attached to it. As the chain is held by the quadrant it is unwound as the carriage returns, and the consequent motion of the barrel is communicated to the spindles in the following way:—Upon the cylinder-shaft close by the disc, there is keyed a ratchet-wheel. Attached to the disc and working in this wheel there is a small movable catch having a tail-piece with two small pins. Between these two pins an arm of a friction-spring which clasps a stationary collar, is passed in such a way that it raises or depresses the point of the catch according as the disc is moved contrary to, or in the same direction as the cylinder; the friction of the spring as it is carried round the collar being always sufficient for this purpose. Fig. 5 shows the position of the catch when the carriage is moving from the beam, and until after the backing-off has taken place. The action of the chain is then felt, and the disc moves in the contrary direction, which immediately brings down the catch upon the ratchet, and carries it round with it, and the cylinders and spindles are, of course, also carried round at the same time.

The length of yarn to be wound upon the spindle is always the same, as it always equals the traverse of the carriage; the speed of the carriage is likewise always the same during the period of building. But until the full diameter of the cop is attained—that is, until the abrupt taper is finished—the quantity of yarn wound up by one revolution of the spindle is always increasing. Just as in the case of the fly-frame the ingenious and complicated differential motion is used to compensate the constantly increasing size of the bobbin, so in this, a most delicate and ingenious, though a simple device is adopted to regulate the speed of the spindles when they are winding up the yarn. Indeed, this may be regarded as the great distinctive feature of the self-acting as compared with the hand-mule. Let us refer to the accompanying illustration (Fig. 6). B B^1 B^2 represents the "quadrant," which oscillates upon a stud at C, and has its oscillation given it by the small wheel F. With every stretch the quadrant describes an arc of 90°. Within the long arm B B^2, and extending its entire length, there is a screw which works a sliding block, D. To this block the winding chain is attached.

Now as the long arm, from being nearly vertical at the beginning of the winding, falls to a position almost horizontal, it will be easily understood that the amount of chain unwound will depend in some degree on the position of the sliding block. If the chain be held at the lowest point, then the amount of unwinding is at its greatest as the effect of the yielding by the quadrant is at a minimum. When the chain is fixed at the extremity of the arm, there will be less of it unwound, by the distance between the two extreme points. When the spinner is about to commence a set of cops, he turns the handle at the top of the long arm until the sliding block has reached the lowest point, if the yarn is to be wound upon the bare spindle; but in the case of "tubes" being used, which gives an increased winding surface, he stops short of this correspondingly. Many appliances are in use for the adjusting of the chain as the spinning proceeds, more or less efficient, but none of them so perfect as to render watchfulness on the part of the attendants, and an occasional shifting of the screw by the hand, unnecessary. An arrangement which has just been patented, and which is perhaps the nearest approach to perfection, is shown at Fig. 6. All motions having for their object the regulating of the degree of tension to which the yarn is subjected, are controlled by the counter-faller. Let us look at the sketch. Upon a stud at B, on the long arm of the quadrant, there swings a sort of pendulum, the lower end of which forms the segment of a circle. This is toothed and works into a wheel which communicates its motion to the quadrant-screw, but, from its peculiar construction, *only* when the pendulum moves backward from the carriage. From the counter-faller, G, a long arm, H H, is suspended. When the winding is taking place, and just before the carriage has reached the beam, this arm comes in contact with a jointed stop fixed to the floor, which throws it back, and it is adjusted with such nicety that if the counter-fuller wire be in the slightest degree depressed lower, on account of the tightness of the yarn, than its normal position, a shoe, sliding loosely upon H H, and suspended by a short chain, takes hold of the toothed rack J, and keeps the arm from falling back against the carriage. On account of the rack being nearly straight, and that part of it which is next to the carriage being nearest to the centre of the arc described

by the loose shoe, its tendency to catch decreases the further back it goes; so that just in proportion to the depression of the faller, is the point at which the arm H is held back, and consequently the amount of traverse it gives to the pendulum when it comes against it through a projecting stud or casting. The movement of the pendulum is communicated to the screw, and the sliding block to which the chain is attached moves towards the extremity of the arm.

When the carriage returns to the beam, and the quadrant assumes a position almost horizontal, the pendulum by its weight swings forward until stopped by a projection upon the sliding block D. Consequently from the shape of the pendulum it will be seen that the greatest traverse is given to it at the beginning of the cop, and that the position of the chain alters more and more slowly until the full diameter is attained, when it ceases altogether. The building of the yarn is then uniform, in the shape of a cone, the yielding of the quadrant being always suited to this, so that the spindles revolve more and more rapidly as the faller guides the yarn from the greater to the lesser diameter.

When the yarn is finer than No. 70 or 80, it is usual to give it a slight stretch after the rollers have stopped, which has the effect of making the thread more even and uniform. An inch to five or six inches, according to the size of the yarn, is about the extent of it, and whilst it is being given the carriage recedes with a greatly diminished speed. Upon the under side of the carriage there are wheels placed in a horizontal position, round which the "squaring bands" are passed, as shown at Fig. 7. These bands are fixed at four points, at the extreme limit of the stretch in front and behind, so that the longest mules are kept comparatively rigid and free from vibration, and also parallel with the beam. At both extremes of the stretch there are stops placed, against which the carriage butts as it reaches these points, so as to cause a positive stoppage of every part.

The hand-mule is much simpler than the self-actor, as several of the movements, such as bringing the carriage back to the beam, and the building of the yarn upon the spindle, are imparted by the spinner. These mules are now principally confined to the spinning of very fine counts.

There are two kinds of yarn spun upon the mule—namely, warp and weft. The latter is ready for the loom when it is taken from the spindle, and is consequently made of a size to suit the shuttle. To render the shuttling of the cop a matter of as little nicety as possible, by preventing the closing up of the aperture which the spindle has left, various expedients have been resorted to. The most common is a small paper tube about an inch in length upon which the yarn is built, and which projects a little from the bottom of the cop. Another is the putting of a little paste or gum upon the first few turns of yarn, which hardens, and is then capable of retaining in some measure its cylindrical form. The spindles upon weft mules are placed usually not more than $1\frac{1}{8}$ inch apart, as that is sufficient space to admit of an ordinary-sized cop. Weft for reeling—that is, to be put up in bundles of hanks—and warp yarn are not restricted in this way, and therefore the spindles are set about an inch and a half apart, and are made somewhat stronger, to prevent vibration. A cop in this case may contain from three to four times as great a length as in the other. Of course it will easily be seen that the advantage is obvious in the less frequent stoppages for doffing.

The throstle-frame is never used for spinning weft, and rarely for warp of a higher count than No. 30. This machine has changed but little in form or principle since the days of Arkwright's *water-frame*. In appearance it resembles the fly-frame, but the bobbins being smaller there are many more of them—300 to 400. The flyers, which revolve at a speed of 4,000 or 5,000 per minute, build up the yarn about the same rate as the front roller delivers it. The bobbin is dragged round by the flyer at its own speed, less the quantity of yarn wound up; and the yarn is kept tight by the bobbin being placed upon flannel washers, which tend to retard it without breaking the thread. The strain of pulling the bobbin round prevents fine counts from being spun upon this frame. The building of the yarn is caused, as in the case of the fly-frame, by the rising and falling of the rail, which is worked by means of what is called the "heart motion."

With this description we must draw to a close our series of papers on cotton-spinning as carried on in this country, and the machinery employed in the work. The comparatively limited space at our command has necessitated a concise treatment of the subject, but not an incomplete one. It would doubtless be easy to go into fuller detail upon nearly every branch of the processes employed, but we think sufficient has been said for our purpose. Considering the vast amount of capital and labour expended upon the spinning and manufacture of cotton in this country, we may hope that our remarks upon this subject will not be among the least useful or interesting to the readers of THE TECHNICAL EDUCATOR.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XX.—SCHOOL MUSEUMS (*continued from Page 375*).

A TRANSVERSE section of the typical school museum described at considerable length in our last paper, showing the arrangement of the end of the lecture-theatre, and exhibiting a sectional view of the museum, observatory, and watch-towers, is given in Fig. 38, upon the next page. D, B, S, C, D, shows the range of doors, battery, sand-bath, and stink-cupboards behind the lecture-table; and L, the disc used for the lantern diagrams, etc., above it, this being eighteen feet in diameter, painted on the surfaced wall with baryta-white paint, which does not discolour in the same way as white-lead pigments. G shows the side-galleries of the theatre. Above is seen the museum, M, with its wall-cases, W, and angle-lighted roof, A A. V V shows the position of gas-pipes and ventilators of the museum, which will come into use when it is lighted up at night. Behind is seen the astronomical observatory, O, surmounting the tower that forms the lift-shaft, the stack of chimneys above the laboratory flues, F, and a watch-tower, T, that surmounts the spiral staircase, and by a door gives access to the roof.

The *Astronomical Observatory* requires careful consideration in connection with the details of construction of any building intended for science schools, as it must be so placed and arranged that the floor on which the telescope stands shall not be subject to any vibrations from without. The best arrangement is to build up a brick tower from a solid base: preferably this should be conical in form, and filled with dry sand, but it may be hollow, the top being covered with a thick stone slab, on which the telescope-stand is fixed. This supporting tower must be quite isolated from contact with the floor on which the observer stands, and also from the walls of the observatory. In my typical plan of construction I have provided for the observatory by making the walls of the lift-tower double, the outer being those ranging with the main building, the inner an isolated hollow shaft, within which is the lift that conveys table-cases, specimens, instruments, etc., from the museum to the lecture-room or laboratories, so that any vibrations from the various floors, walls, etc., cannot be imparted to it, as it is in no place in contact with them, as represented in elevation in Figs. 37 and 38, the latter diagram also indicating the position of the stairs, S, from the floor of the Arts School, by which access is gained to this observatory, and the manner in which the telescope-stand is isolated from the floor and walls of the observatory.

The proportions of the external walls of this tower will depend upon whether a refracting or reflecting telescope is to be adopted, for as the former requires that the observer should lie on his back, it demands greater space than for the latter, where the observer stands in the more convenient position, *beside* the instrument. An observatory 6 feet square would be sufficient for Browning's "Educational Reflector," of $4\frac{1}{2}$ inches diameter and 5 feet focus, provided with alt-azimuth and parallactic motions, designed especially for school purposes. It is well to bear in mind that, while a good reflector is as efficient as a refractor, it is considerably cheaper; but those interested in the question of reflectors *versus* refractors will find the subject fully discussed and illustrated in Mr. Browning's "Plea for Reflectors." To secure equality of temperature, the walls of the observatory should be made of sheet iron, extra space being at the same time gained. A small room for the reception of a transit instrument should be connected with the observa-

tory, or the tower T (Fig. 38) might be made available for the purpose. A large tank should be placed on the roof, to keep the laboratories well supplied with water.

Such a range of buildings would provide ample and suitable accommodation for teaching science in our great schools on a proper scale, and if at first sight this typical plan is suggestive of heavy outlay, we may fairly ask if costly piles have not been erected for the very simple requirements of classical and mathematical instruction, and whether science, so intimately associated with modern professional occupations, has not equal claims for buildings adapted to its special necessities. There need be little fear but that ample funds will be forthcoming to provide both the necessary materials and structures, when such testimony as the Masters of Rugby bear—in answer to the question, "What are the general results of the introduction of science teaching?"—has been multiplied. Mr. Wilson answers this question for the body of masters as follows:—"In brief it is this, that the school as a whole is the better for it, and that the scholarship is not worse. The number of boys whose industry and attention is not caught by any school study is markedly less; there is more respect for work and for abilities in the different fields now open to a boy; and though pursued often with great vigour, and sometimes with great success, by boys distinguished in classics, it is not found to interfere with their proficiency in classics, nor are there any symptoms of over-work in the school. This is the testimony of classical masters by no means specially favourable to science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the results of their two or three years in our middle school, the introduction of science into our course has been the greatest possible gain; and others who have left from the upper part of the school, *without hope of distinguishing themselves in classics or mathematics, have adopted science as their study at the Universities.* It is believed that no master in Rugby School would wish to give up natural science and recur to the old curriculum."

Construction of Local Museums.—The term "Local Museum" has been applied to such small collections, housed in small rooms, as the late Mr. Toynbee described in his little book on the Wimbledon Local Museum; but here I employ the term in its wider and general sense, as applied to provincial museums of all descriptions that aim at displaying "typical collections," as well as "local collections;" for they exist under such a variety of names, I hardly know how to select a better designation of general significance, unless it be the term "provincial museum;" but I include such institutions as that opened a few years ago in the east of London, under the title of the Bethnal Green Branch Museum of the South Kensington Department of Science and Art, as an example of similar branch museums to be established in other parts of London and its suburbs. In the construction of our local museums, the scientific man has unfortunately seldom if ever been consulted as to the practical wants of the curator or lecturer; but the entire design has been left to the architect, who, as a rule, is perfectly unconversant with scientific requirements, and thinks it beneath his dignity to confess as much, and seek the advice of those who could aid him; while, guided by the instincts of human nature, he throws all his thought into general "effect," especially over the exterior, which will be a standing advertisement of his architectural ability to those who are town councillors—not naturalists! Thus it is, money has been lavished over the music-hall-like interior of the Hartley Institution of Southampton, and the massive Gothic exterior of the Devon and Exeter Albert Memorial Museum. In the former case, the lecture-hall is more suited for concerts and town council addresses than for lecture purposes, being of great length, the floor occupied with seats on a uniform level, the sides with two tiers of galleries, like the boxes of a theatre, with a great semi-circular concert-gallery, entered by large doors at the back, immediately above the head of the lecturer; so that it is difficult to make the voice heard and experiments seen by all the vast audience the place is constructed to hold. As might be expected, the space available for the museum is small, and that required for other scientific purposes is totally unprovided for; though the object Mr. Hartley specially had in view when he made the munificent bequest of over £89,000 was for the benefit of "the select scientific public." At the Exeter Museum the Gothic walls are *over two feet thick*, which consequently leads to many of the rooms being badly lighted, including those devoted to the typical and ethnological collections on the ground floor. The top-lighting of the "local museum," on the upper floor, is marred by a side-light in addition, which produces an effect of glare. *There is no lecture theatre*, and some of the best rooms formerly devoted to science classes have been annexed for extra reading-rooms for the free library. Much space is wasted over the entrance arcade, vestibule, staircases, etc., and a number of little rooms in the front of the building, which would have been turned to good account if any scientific person had been consulted; the architect having given more attention to the external effective appearance of his design than internal conveniences for scientific requirements, and so much money was devoted to this mistaken end, that little was left for providing necessary cases for the proper display of an extensive and excellent collection of general and local specimens, a large portion of which are obliged to remain packed away, instead of being displayed for public inspection. Having given two well-known examples of architectural miscarriage in relation to museum construction, I may state that I believe the elastic typical plan I have given for the science buildings of a school will equally meet the requirements of a local museum, if we replace the external staircase leading to the first floor with a large and handsome double staircase, and build in front, to the height of the three stories, a large and lofty entrance-hall, entered from without by a pillared portico, preferably of a size that would admit of carriages being drawn up beneath it. The sides and front of this entrance-hall might have the window spaces fitted with large and lofty plant-cases, for the ornamental display of palms, tree ferns, and other tropical shrubs, plants, etc. The room P N, forming the natural history work-room in the school arrangement, might in this case be devoted to a reading-room. I see no reason why a building that is professedly a museum should not have its doors and windows treated, internally, as illustrative specimens of different styles of architecture in different ages. The selection of the heating apparatus of a public institution requires care, or it may prove a matter of great annoyance, if not injury to health. I believe the hot-water system is usually preferred to the hot air, as the latter is considered unpleasant, and the smell from the flues is often very objectionable. In building any local museum, the first effort ought to be to produce a shell, fitted with the most convenient arrangements human ingenuity can devise for the wants of curator, teacher, and student, and when *that* has been accomplished, *then* devote any surplus funds to the external ornamentation of that shell in any manner good taste may direct, as long as the design will not interfere with the effective lighting of the several departments; at least, this is *the naturalist's*, if not *the architect's*, view of the question.

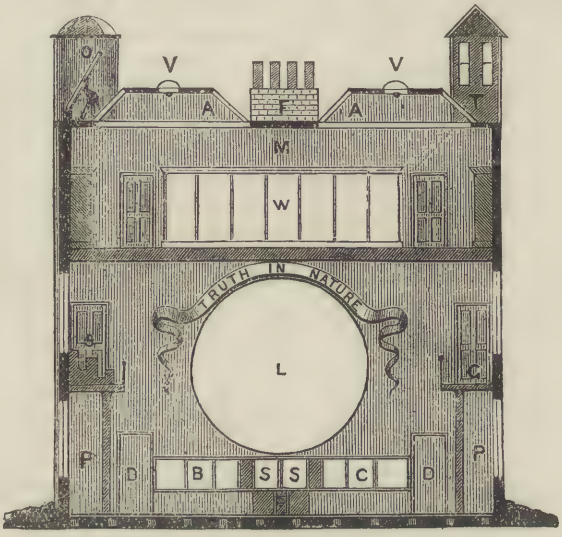


Fig. 38.—TRANSVERSE SECTIONAL VIEW OF SCHOOL MUSEUM.

PRACTICAL APPLICATION OF THE FINE ARTS.—XVI.

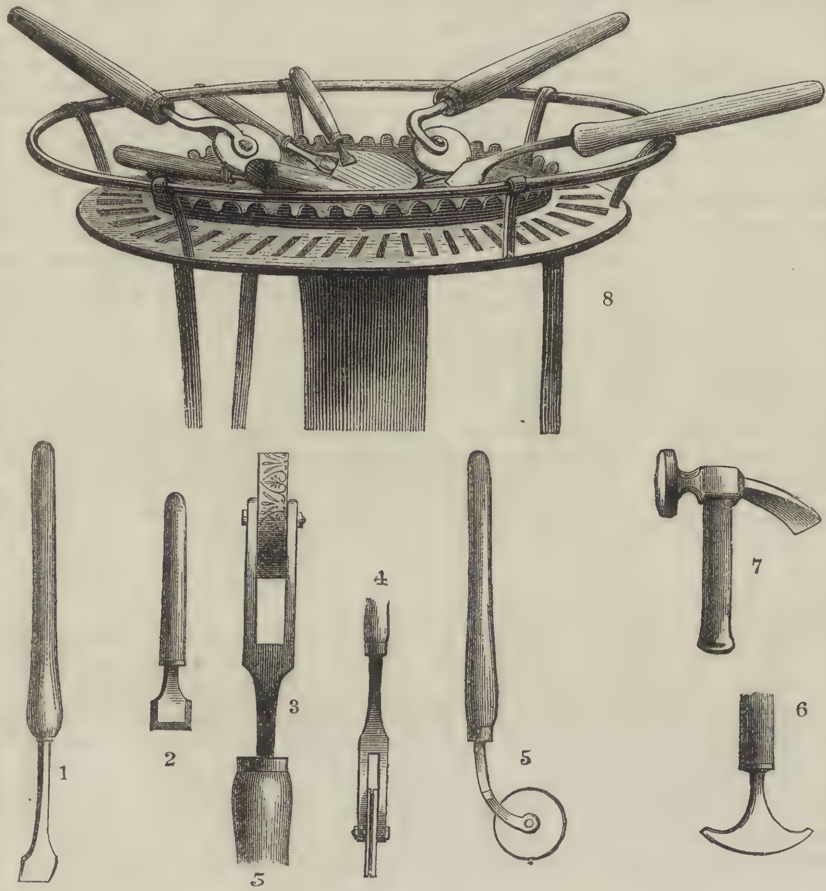
By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING (*continued*).

Cloth Binding.—In France and Germany it is the habit of publishers to sell their books simply in a paper wrapper, the sheets being folded, but not even stitched as our magazines are. This would not suit the English market, where many books are sold which the buyers do not care to have bound in a strong and consequently somewhat expensive cover, and yet which, being read by several persons, require something more than loose paper to keep them together. This applies not only to novels and ephemeral publications, but many more substantial works which are bought for perusal at the time, their owners waiting for a more convenient time to have them fully equipped to join the serried ranks upon their book-shelves. Hence the wholesale cloth binding for publishers. There are many points in this style of binding which differ from the stronger and more expensive work.

Sawing the Back.—In the first place the sawing the backs is done by machinery. The sheets being folded and compiled, several copies of the work—the number of course depending upon the thickness, *i.e.*, the number of sheets of each copy—are taken by a workman, who drops them on the flat plate of his machine on their backs first, and next on their top edges, thus getting all these portions quite flat; then holding the whole mass of sheets with the backs downwards, between his hands, he slides them along the steel plate, keeping the top edges against a guide placed at the back, and in this way they traverse over some circular saws, the teeth of which rise a quarter of an inch above the plate. The number and distance apart of the saws depend, of course, on the number of bands it is intended to give the work, and these can be regulated either with screws or stops on the spindle on which the saws turn. The saws leave a shallow groove in the backs, which just penetrates the sheets as far as the crease, thus making a slight hole for the sewer's needle to go through, saving both time and labour in pressing the needle through, and also allowing the band to be within the groove. The bands must needs be sewn on evenly with this line to guide the thread. With this assistance a woman can sew as many as two or three thousand sheets in a day. Sometimes tape bands are used instead of string. The women employed in this work get as much as fourteen shillings a week. After the bands are sewn the whole back is often covered with a piece of canvas, which extends about half an inch beyond the paper, and which when glued to the boards affords some additional protection to make up for the want of security in not running the bands through the boards, which is seldom done in rapid work.

Backing Machine.—The backing is another process that is done by machinery. The book is placed in a press between two iron plates, leaving about half an inch raised above the press, the pressure being applied by the foot whilst a steel roller of some two or three inches diameter is brought down by the hand upon nearly the centre of the back; this roller, the axis of which works on arms, which allow it to move backwards and forwards to and from the operator in the arc of a circle, is pressed downwards on the back, and moved first to one side and then to the other, pressing the back out in each direction, and leaving an ample margin, so that the boards when applied sink into a place ready fitted for them. The crease in this case will be perfectly even and smooth, but the amount doubled in will be greater in most cases than when the work is done by hand with the backer's hammer. Even in this case, however, the hammer is not entirely dispensed with, for when the books are thus pressed it is necessary to give them a blow or two first to ensure their taking the right direction under the roller. With this machine a single man can back as many as twelve hundred books in a day, whereas by the hand the time taken to each book is considerable, and the larger the book, and the better the style of binding, the longer becomes the process.



TOOLS, ETC., USED BY BOOKBINDERS.

1. Polishing Iron. 2. Pallet. 3. Roll. 4. Two-line Roll. 5. Fillet. 6. Pallet. 7. Hammer. 8. Gas-stove for Heating Tools.

Cutting the Edges.—The books are now roughly cut by a large knife which works by steam-power. This is only a preparatory process in order to avoid rough and uneven edges, and it does not do away with the necessity for the paper-knife, but after the work is put into boards it is often cut again; this is a more delicate and careful process, though similarly performed.

Covers.—In this kind of binding the boards and their cloth covering are applied at the same time, and all pasted on at once to the back and bands, canvas and lining sheets. The preparation of these covers forms a remarkable exemplification of how far machinery can be adapted to the multiplication of beautiful forms. When we look at some of the charming cloth covers which about Christmas time especially we see lying on booksellers' counters, resplendent with bright colours, covered with elegant designs, and with portions of their designs stamped in other colours and lavishly bedizened with gold, it is scarcely possible to imagine that large editions of such works, consisting

of one, two, or three thousand, have passed through the binders' hands with only three or four days elapsing from the time that the sheets left the printer's workshop until the time when the publishers had the works returned to them in a state fit to put forth in all their glory and splendour, before a public which has to be captivated with a new, striking, and elegant cover. But such is frequently the case, and whilst we were inspecting the Temple Works, belonging to Mr. Matthew Bell, we were shown covers then only in the first stage of preparation, the sheets to go inside which were not yet arrived from the printers, but of which 1,000 copies had to be delivered to the publishers in but little more than forty-eight hours from the time we were there. The mind can scarcely conceive much more rapid work than this.

Stamping.—These covers are made of two thin boards, somewhat firmer but not much thicker than stout brown paper, with a strip between them for the back of even lighter material. These three are all covered with the cloth already glazed. The pattern is impressed upon them by a powerful steam-press, which will if required stamp both sides and the back at once, when the back has an uncoloured stamp or one with the same colour as the sides; but inasmuch as the two sides frequently have the same design on them, it is usual to stamp one side and the back first, and then to go over the covers again, stamping the other side with the same plate as the first side was done with. These plates are of thick brass, and though they do not readily wear out or get broken—yet this occasionally happens through displacement whilst the steam-press is in full work and cannot be stopped—still the demand for novelty is so great that there is much room for designer's work in this department. In some cases the covers are simply stamped; in others a stamp is imprinted, and at the same time a colour is also applied. This is done much in the same way as in ordinary printing, a roller covered with the ink being passed over the plate whilst the press is up, and being withdrawn on a plate which spreads the ink by constant movement whilst the press is down upon the cover. In some very elegant designs we have seen both these elements are combined; a portion of the pattern is first stamped plain, and then another portion is stamped in colour, whilst the whole is enlivened with gilding by a process we are now about to describe.

Gilding and Lettering.—In a long room a number of boys are seated each at a kind of desk. These prepare strips of gold-leaf by cutting them into the requisite shape. Economy in this respect is of the utmost consequence where things are done on such a large scale. The strips of gold are fixed on the various parts of the back or sides where the gilding is required. The covers thus prepared are then delivered to a man who sits at a press very similar to the one we have referred to before, for stamping the boards, but with this peculiarity;—that the plate, or, as is sometimes the case, the type, set up in a plate, is fixed to the upper and movable part of the press, which is made hollow for the reception of a stream of steam which keeps this plate at a fixed temperature; beneath is a piece or two of mill-board which has taken the impression of the plate above it. To this press is subjected the cover with its own portion of gold-leaf; the hot plates come down upon it, leave their stamp, and by their warmth fix the leaf within the sunken parts. The cover is now returned to a boy, who wipes off with a piece of rag the superfluous gold, which is easily detached, and it is finally rubbed well with Indian rubber.

Paper Covers.—For very cheap books paper-covered boards are prepared, only that instead of being stamped they are printed. This gives scope to any amount of variety, and not only a pattern, and the name of the book, but also a scene from the subject of the work, printed in one or more colours, is not unfrequently given, together with advertisements on the back.

The covers thus prepared are simply glued and pasted to bands and lining paper, and then it is ready for the common use to which such works are subjected. The strength, of course, of such work is not great, and it is not intended by these temporary covers to do away with the necessity of more substantial binding for books that deserve more attentive perusal than much of the current literature of the day demands.

BOOKBINDERS' TOOLS, ETC.

The instruments used in the ornamental portion of bookbinding, though innumerable in actual detail, may be classed under very few heads; in fact, they may be arranged into those that are fixed and those that turn on their own axes. Those that are fixed are called pallets, whilst those that turn are named fillets and rolls. Amongst our illustrations, Nos. 1 and 7 are distinct implements. The first is a polishing iron, for smoothing the backs of books, and the last is the hammer used in backing, to which we referred in a former paper; neither of these can well be reckoned among the instruments in the ornamental portion of bookbinding.

Pallets.—Pallets are used where a certain definite figure has to be impressed, as, for instance, the tool from which our illustration 6 is taken, is employed to mark the double lines which we commonly find on each side of the false bands on the backs of large books. The reader will remember that the bands which are apparent on books whose backs are detached from the actual leaves, as is the case in almost all books at the present day, are only artificial imitations of the true bands, which must necessarily be concealed beneath the back, on which false bands appear. On each side of these bands lines are usually impressed, sometimes only in blind-tooling, and sometimes with gilding. These lines are formed by pressing the curved pallet, such as Fig. 6, on the back with considerable force, after the instrument has been heated to the proper temperature. If the lines require gilding, the tool is again warmed, a piece of gold-leaf is attached to the tool, and the latter is again pressed into the impression which it has made for itself in the back. In the case of large surfaces, and where any portion has been left uncovered with gold, the process is repeated, and of course it requires a considerable amount of nicety and some experience to direct the instrument three times exactly into the same spot, for if this be not done, naturally the impression is blurred and irregular. Pallets are also used for all kinds of small devices, which are to be impressed upon the sides of the book as well as upon the back. It will thus be seen that though the classes of instruments are few, the actual number employed may be innumerable, since every separate device requires its separate instrument. Every curve, every line of various thickness, every leaf, and each size of that leaf, requires to be cast in brass, and properly shaped to the intended form. A man with an extensive business, who cares really to execute a variety of designs, and produce objects pleasing to the eye from their variety and originality, must keep an enormous collection of tools, and must never scruple at adding to his store, however large it may be.

The instruments that turn on axes are divided into two classes not really differing much one from the other—viz., fillets and rolls. The only distinction between these is that the fillets produce lines of various thicknesses, sometimes single, at other times double, or with greater numbers, sometimes the lines all of the same breadth, and sometimes of different thicknesses; whereas the *rolls* are covered, as may be seen in Fig. 3, with a complicated pattern. Here again there is room for great variety, though hardly so much as among the fillets, since lines can scarcely be multiplied beyond a moderate number, and the complicated patterns produced by rolls are not pleasing when too often repeated. All these tools are formed of brass, and are fitted into stout handles, usually of ash, since they are used with a considerable amount of force.

Temperature.—The process of heating requires great care and large experience. Each kind of leather requires a different temperature. In order to simplify the acquirement of the necessary heat, a small gas-stove, such as is portrayed in our illustration, is made use of. In the centre is a modified form of the Bunsen burner, and above this is placed an iron dish having a hole in the centre, which allows the direct heat of the flame to ascend through it, and which also has a couple of rims raised around it with a number of notches in them. These notched rims retain the tools at any distance from the central flame, the handles being supported on a bar surrounding the whole apparatus. The tools can be made to rest on this in such a manner that they can be heated quickly over the hot flame, or they can be kept at any temperature whilst other work is being pursued or another tool being used. When the tool is sufficiently heated it is applied to the leather, which is damped either with weak acid or with water, as we described before. The instrument is held in the right hand, near the junction of the brass and the wood, and the end of the handle rests against the shoulder. The amount of pressure is then produced by the leverage be-

tween the hand and the shoulder. In the case of pallets curved as in No. 6, by the workman leaning forwards or backwards the various portions of the edge are brought in contact with the different parts to be impressed; and in like manner with the rolls, the gradual motion of the whole body produces a uniformity of pressure which ensures an evenness in the pattern. Where direct pressure alone is required, the position of the workman may be seen in Fig. 3, page 41 of the present volume.

Proportion.—Another most important point in design must be the keeping a proper relative proportion between the various parts. We constantly see that a certain plain space has to receive some kind of ornament; the tools are looked over, and one is chosen which, by turning on one side perhaps, will just fill up the space. Here all proportion is lost. If a drawing or an engraving is put into a frame that just fits it, half the effect is gone; let it, however, be allowed a margin which is half as wide as the picture itself, and the effect is enhanced in a marvellous manner. If a star is enclosed in certain boundaries, the points of the star should not pierce the sides of the figure by which it is surrounded, but it should have a certain space to shine in. In order to make the indentations of the pattern appreciated, there must be a considerable expansion of even surface with which to compare and contrast it. Even surfaces must contrast with highly ornamented parts, and the foundation colour should form a foil for that which is inlaid on it. An agreeable effect, too, is produced by the gold or deep-coloured border-line stopping where another pattern comes across it, and thus producing the appearance of the one pattern crossing the other. This should be sparingly indulged in, for, if frequently employed, it becomes wearisome.

Time and Study.—For all these variety of details it is necessary that time should be employed. It is impossible to produce a really good design in a short time, and if experience may afford a seeming facility, it is only because forms used before recur to the memory and come into employment again. As in all designs, the general idea must first be sketched out, and afterwards the details finished; it is useless to begin upon the details and try to fit the design to the detail afterwards. Mere running lines about, without any object, will not eventuate in any pleasing work unless the eye has the power to choose out the beautiful among a variety of worthless designs. So, too, colour should not be put on unless it be to express some clearly-defined idea. Books for constant reference, or on serious and important subjects, are better covered in deep and sober colours undiverted by lighter tints; but works which are designed more to amuse than instruct should repeat in their covers the lightness and variety of their internal ideas. So, too, with the temporary covers in which publishers send out works; these necessarily are of a lighter and brighter character than the more permanent clothing that books receive when they have a place assigned to them for repose on the shelves of the library rather than of the reading-room. We give a specimen of a cloth cover, which will serve to illustrate our remark. The design should be light, but it is not only so in design; the nature of the material allows of a great variety of colour, and naturally striking colours are most attractive in the eyes of those who wish to draw attention to their wares. But though the designs on cloth covers are to be attractive and striking rather than grave and solid, there is no reason why good taste should not prevail in their production. The combination of lines may be boundless, and without being eccentric there is plenty of room for variety and for beauty. One great fault to avoid is the overcrowding of ornament. As the exterior case is not intended to last for any great length of time, there is no occasion to squeeze all the ornamentation we can think of into a small space. Both publisher and reader wish rather to be able to distinguish the work by its cover, than to be led to examine minutely the lines of beauty on the outside. Variety of colour, therefore, is a primary consideration. This of course is easy enough now-a-days, with the innumerable dyes and the facility for modifying the various tints of each colour. Upon these various tints, both gold and other colours, and especially black, can be printed. It is scarcely possible, therefore, to go far wrong as regards colour, for there is no temptation to multiply colour when each additional printing costs more, and the brightness of the impressed colours is naturally to a considerable degree lost. Black or a dark colour upon a single tint, relieved with a small amount of gold, which will add naturally to almost every tint, leaves but small room for mistakes in regard to colour. The principal point, therefore, in cloth binding is form. Now a study of the combination of lines in all kinds of ways is the only means to increase taste in the matter of lines. Of course a true artist has the purest appreciation of the value of lines. A course of study in an art-school will do much to produce a true taste in this matter. And as all artists are recommended, when they wish to prepare themselves for any course of painting, to study the anatomy of the human body, and to draw from the living model, so no one can hope to accomplish really satisfactory designs who does not go to Nature to discover the secrets of her graceful combinations of lines in all natural productions of the animal, vegetable, and mineral worlds. It must be remembered, however, that in these designs we are not reproducing Nature, and in bookbinding a very good lesson in ornamentation is soon brought home to the student. He cannot, with the very limited materials for producing lines which are at his command, reproduce the infinite variety of natural objects; but what he has to do is to idealise natural objects, and then to introduce all the variety of their application he can. Nature, for instance, never gives a straight line, but in a design for a cover we *must* have many straight lines. The curve which a natural object suggests is never fully carried out; there are always imperfections, breaks, interruptions, new ideas breaking in; the brass tool must be of a perfect curve, or it is useless; interruptions are scarcely permissible; old ideas must be fulfilled before new ones can be entertained. That which causes the charm of natural objects, the constant development of something fresh, is entirely unsuited to the ornamental design. If a man therefore intends to work out a design, of which some particular kind of leaf or flower is to be the groundwork or the leading principle, he will not copy one solitary leaf, however beautiful in itself, but after studying (best with pencil in hand) a great number of examples of the object proposed, he will then, laying aside the work which he has done, draw such a leaf or flower as he has never yet seen, but such as all these various examples have pointed out as the model from which they have more or less departed. He may then advance another step, and noticing the peculiarities which distinguish this kind of leaf from the others with which it is most closely allied, he may exaggerate those peculiarities, leaving out the portions in which his model is similar to other leaves. In this way he arrives at a mere ornament like the fleur-de-lis or the star, neither of which is, excepting in a conventional way, suggestive of the name it bears.

SPECIMEN OF MEDALLION ON A CLOTH COVER.

In some of the examples we have given, a single leaf is made the foundation of the greater part of the ornament: we may instance the work of Nicolas Eve and Belz-Niédrée. The lines and curves of the twigs are numerous and varied, the leaves are put on these twigs in various ways, but the leaf is the same, not even a difference of size. Nothing can be more elegant and refined than the conventionalised oak branches in Belz-Niédrée's work. The curved lines, not at all such as one would really find in oak branches, contrast most pleasingly with the severe straight lines and sharp angles of the rest of the pattern. The thickly placed leaves in the other, with the constantly recurring berry between every two leaves, is also unlike anything in Nature that one has ever seen; yet the effect is pleasing, and it has for its foundation these natural objects.

The binding of Grolier and his men (Grolieri et Amicorum; not Grolier and his hands, or his workmen, but his friends—what master now so describes his assistants? how would not such a man love his work and the books he preserved, who thus

spoke of his associates in the work?) is a good example of rich yet simple design. In the centre is a species of quatrefoil suggesting a cross, longer in the direction of the length of the book. The lines next the edges are parallel to those edges, and unbroken until they approach the corners, when they take a sharp circular curve inwards, and in this respect are more pleasing than other examples of the same artist. These two sets of lines are combined by the inner border parallel to the outer one it interlaces; the inner figure, again, by its rhomboidal shape surrounds the quatrefoil, and it also touches the outer lines. All these lines, therefore, are interdependent upon one another; they are all different in character, and yet are all combined and are suggestive of one another. Nothing has been used so far but straight lines and portions of circles, but these portions have been all different, and the straight lines of various lengths. There remain spaces to be filled up. In order not to suggest weakness at the corners, a rather elaborate ornament is introduced which entirely fills up the space. This is not independent, but by a delicately curved line is attached to the outer line of the border. Each of the blank spaces is then filled in with ornaments which adapt themselves to the position they have to take, but at the same time leave an ample margin round each. For instance, a conventional rose in the three-quarter part of the circle suits its position admirably, but it is not repeated in those leaves of the quatrefoil which are broken by a straight line. Again, in the border, where long spaces are left between the points of the diamond and the corners, a cipher introduced takes the main outline of an oblong; the little flowers at the corners of the inner border line are turned on one side, but it is in order to point to the corners to which they approach. Thus all is pleasant and harmonious, and a design is produced which requires no artificial assistance from colour, but which nevertheless would easily admit of its introduction.

A careful study and analysis after the above manner of the best works of Maoli, Le Gascon, Clovis Eve, Nicolas Eve, Hardy-Menil, Belz-Niédrée, Banzonet, and our great English binders, will well repay the time and labour expended upon them.

CIVIL ENGINEERING.—XXVI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

Before raising the superstructure, it is necessary to determine the strength and thickness of the abutments which have to resist the thrust of the arch. The difference between the functions of the piers and the abutments of a bridge is very marked. In the case of a single arch with two abutments, although the key-stone and voussoirs effect an equilibrium amongst themselves, yet the whole together exercise a very considerable amount of lateral thrust against the spring on either side. The amount of such thrust will vary with the curve of the arch, but in every case it is very great, and must be carefully guarded against. In the case, however, of a bridge consisting of two or more arches, the abutments still have to bear all the lateral thrust, whilst the office of the intermediate pier is simply to sustain the weight of the superincumbent masonry, because the two opposite springings of the arches balance their respective thrusts, or else simply transmit the thrust to the next arch, and finally to the abutment. Hence a pier may be made as light as is consistent with the duties it has to perform, so as not to impede unnecessarily by its size the water-way, as already adverted to.

The strength of an abutment is a point dependent upon various conditions, such as the flatness of the curve with which the arch is struck, the weight of the arch, the height of the abutment, and so forth.

The following formula will give the thickness of an abutment without wing-walls, possessing quite sufficient strength to resist the thrust of the half-arch, supposing the same material is employed both in the arch and the abutment, the depth of the crown being equal to $\cdot 4\sqrt{R}$, in which R = radius of arch at the crown in feet:—T (the thickness) $= \sqrt{\frac{R^2}{5} + \frac{3R^{\frac{3}{2}}}{5} + \left(\frac{W}{H}\right)^2} - \frac{W}{H}$, in which W = weight in cwts. of 1 foot lineal of half the arch, and H the height of the abutment to the spring in feet.

Another point of importance, independent of the thickness of the abutment, is the tendency of that portion of it from the line of thrust upwards to slide back over the masonry below this line. Now here it is evident no precise rule can be given for the avoidance of such a result. It is a question dependent principally upon the material employed as mortar or cement, added to the weight of the superincumbent mass. The question of the adhesion of cement and mortar is one of great interest to the engineer. In 1804, M. Boistard published some experiments upon the subject, and the conclusion he arrived at was what might have been expected—that the adhesion of mortar is proportioned to the surface, and that after the lapse of a few weeks the value of the adhesion ceases to increase. He considered that the adhesion of a square metre of surface of set mortar, composed of lime and sand, was equal to 15,312 lbs., and if composed of lime and cement to 8,140 lbs., both results being regarded approximately. With respect to the friction, the same author ascertained that it bears a constant relation to the superincumbent pressure, being equal to about four-fifths of the pressure: and here it may be observed that the flatter the arch the greater is its tendency to induce a sliding action in the upper portion of the abutment, simply because the thrust is more horizontal; whereas, the more curved the arch, the greater is its tendency to overturn the abutment. In both cases, however, one fact becomes

Fig. 84.

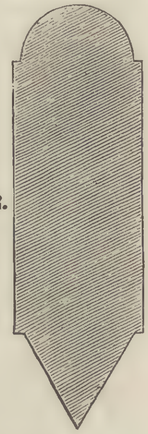


Fig. 82.

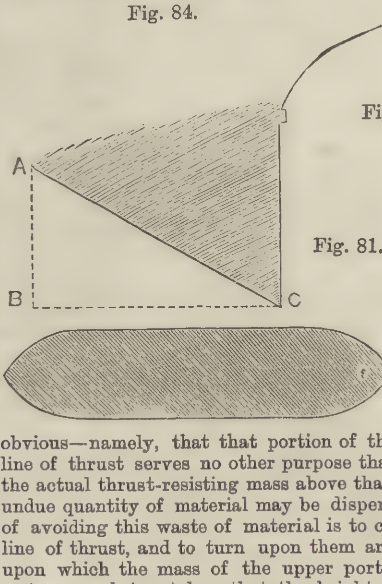


Fig. 81.

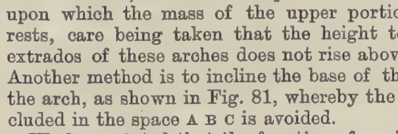


Fig. 83.

obvious—namely, that that portion of the masonry below the line of thrust serves no other purpose than that of supporting the actual thrust-resisting mass above that line, and hence any undue quantity of material may be dispensed with. One plan of avoiding this waste of material is to construct walls in the line of thrust, and to turn upon them arches of small radius, upon which the mass of the upper portion of the abutment rests, care being taken that the height to the crown of the extrados of these arches does not rise above the line of thrust. Another method is to incline the base of the abutment towards the arch, as shown in Fig. 81, whereby the mass of material included in the space A B C is avoided.

We have stated that the function of a pier is mainly that of supporting the actual weight of masonry resting upon it, and of transmitting the thrust of the adjacent arches. This is correct, and in this view only the size of the pier may be advantageously reduced to a minimum. But other considerations have to be dealt with. It is proper to consider what would result in the possible event of a pier being carried away from some unforeseen cause. Supposing any pier in a prolonged series of arches were removed, and each of the other piers could do no more than fulfil the functions stated above, it follows that the equilibrium of thrust being removed by the fall of one pier and its adjacent arches, all the others must yield in succession to the one-sided thrust thus brought to bear upon them, and the ruin would become general. For this reason it is desirable to give to a pier which is associated with other piers in the same bridge a greater amount of strength than is actually required for the fulfilment of its purpose as a pier. As an illustration of the dif-

ference between theory and practice in respect of the dimensions of a pier, it may be stated, in the bridge at Neuilly, constructed by Perronet, the piers are about 14 feet in thickness, whereas the same engineer has calculated that they would perform their functions as *piers* if reduced to 13 inches, although with such a reduced area the stone composing the pier would be supporting a weight sufficient to crush it. But whatever be the reduced dimensions of the body of a pier, care at least should be taken that the base is spread over a considerable area.

We have in a former part of our treatment of this subject alluded to the forms of the "starlings" of the piers of bridges. The starling is that portion of the pier which faces the direction of the stream, and acts like the cutwater of a ship. The ancients were in the habit of giving the form of a semicircle, or else a triangular form, to the starlings of their piers, as shown in Fig. 82, and we are not prepared to find great fault with them; but modern engineers have made the matter a subject of calculation, and the usual form now adopted is that of a Gothic arch, as shown in Fig. 83.

It is, however, a remarkable fact that if the starling is altogether omitted, and the pier terminated abruptly, presenting a flat surface to the current, the flow of the water is less obstructed. There is a reason for this apparent contradiction. As the current strikes against the opposing pier it becomes in a measure heaped up, and forms in consequence a mass of dead water extending not only along the entire face of the pier-end, but for a certain distance past the angles; and this mass acts as a guide to the succeeding current, warding it off, as it were, from the pier, and giving it a regular and gentle flow past the sides. But the danger resulting from the regular flow of a current is, in its effect upon a pier, small as compared with the danger arising from the undermining of the pier itself. The contraction of the water-way must obviously increase the rapidity of the stream, and this, it has been shown, acts detrimentally upon the bottom. Now the action of a flat starling or pier-head is to throw the current away from the pier itself, and to divert it into the middle of the adjoining arch; here, therefore, there is a concentration of the current, and a consequent increase of velocity. This should be avoided.

The results obtained from a series of experiments made with starlings of various forms have been to give a preference to the elliptical pier-head, making, in fact, the section of the entire pier an elongated ellipse, as shown in Fig. 84.

If a triangular form be adopted, the equilateral is preferable to the right angle; but the form given in Fig. 83 is an excellent one, and presents, at the same time, a lightness in character which is agreeable in an architectural point of view.

The actual construction of piers and abutments is a matter of the greatest importance; a good foundation will in this case avail but little if the superstructure is imperfectly united. Hard stone should always be selected for the purpose, and the outside courses should be laid in headers and stretchers alternately. The size of the stones must depend upon circumstances, but they should not be too long. Less care in regularity may be observed in the interior filling in, but this also must be substantially put together.

After the piers and abutments are raised, and sufficiently consolidated, the centres are put up, and rest upon projections left for the purpose in the sides of the piers, or upon piles placed close to them. They should rest directly upon double wedges, so that they can be adjusted bodily accurately to the exact height required. The voussoirs can now be placed in position; and to prevent an undue pressure upon the centres, they should be laid from each side simultaneously, and close with the key-stone. Care must be taken that the line of joints between the respective voussoirs corresponds accurately with the radii of the arch at those points. The thickness of the crown of an arch will depend upon the radius of the curve with which the arch is struck. No certain rule can be laid down for this, but experience has shown that it may vary from less than 6 inches in an arch whose radius is only 2 feet, if the material be stone, to about 4 feet if the radius be 160 feet. If brick be used, these dimensions must be considerably increased—namely, from ·56 ft. in the former to over 5 feet in the latter.

Fig. 85.—PERSPECTIVE VIEW OF A SINGLE ARCH OF LONDON BRIDGE.

With respect to the pressure which it is safe to bring to bear upon the arch-stones of a bridge, it is obvious it is a matter wholly dependent upon the character of the material. This is evident from the relative dimensions just assigned for the crown of an arch, whether consisting of stone or brick. The crushing which stone of various kinds will bear has naturally been made the subject of careful experiment. We subjoin a few facts, the result of observation:—

DESCRIPTION.	Crushing force in lbs. per sq. inch.
Brick	1,500
Brickwork in cement	1,000
Portland cement	1,000
Granite	8,000
Limestone	5,000 (average)
Marble	6,000
Sandstone	5,000
Portland stone	3,700
Slate	11,000

These constitute the materials usually employed in masonry.

Instances are on record of engineers having employed stone in positions where too close an approach has been made to the yielding power of the material, notably in the pier of the Chapter House at Elgin, forming a portion of the remains of the once beautiful cathedral there, but it is not a wise step. As a rule, the greater the pressure the greater should be the area over which the pressure is spread, and it is not safe to exceed one-tenth of the actual yielding-point of the stone; nevertheless,

it is a remarkable fact, as observed by Mr. Gauthey, that the strength of stone increases in a higher proportion than the surface of the base extends.

We shall close the subject of masonry bridges by some extracts from the specification of the work which was required for London Bridge.

The *coffer-dams* to be elliptical; all the piles to be whole timbers of the best Baltic fir, and not less than 12½ inches square. The main dam to have two rows of piles 5 feet apart, and not less than 5 feet above high-water mark of spring-tides when driven, connected together with three rows of double whole waleings, secured by 2-inch iron bolts at every 10 feet apart, with plates and nuts. The main dam to be surrounded by an outer row of whole timber piles 6 feet from the next inner row, connected by three rows of double whole waleings, 12½ inches square, and secured to the main dam by long wrought-iron 2-inch bolts passing through all three rows of piles at each row of waleings. The spaces between the three rows to be filled in with well-beaten clay, and the exterior joints caulked and pitched. The whole dam to be braced longitudinally and transversely with timber braces, struts, and iron straps. The dams to be fitted with three sluice-gates, placed in the upper, middle, and lower tiers of waleings. All the piles to be shod with iron, and hooped at the top.

The earth for the foundations of the abutments to be taken out to a depth of 34 feet 6 inches at the front below high-water mark, and 25 feet at the back. The earth for the two side piers to be taken out to a depth of 40 feet, and that for the remaining piers to a depth of 43 feet below high-water mark. The piles to rest the piers and abutments upon to be of elm, fir, or beech, not less than 12 inches diameter in the middle, and 20 feet long, shod with iron shoes weighing 35 lbs. each, and hooped at the top with iron hoops 30 lbs. weight each. The piles under the abutments to be driven at right angles to the inclination of the floor, and those for the piers perpendicularly, and not less than 18 feet into the solid ground, and in rows 4 feet apart from centre to centre. The heads of the piles when driven to be cut off level, and 9 inches of earth to be removed from between the heads, and the space filled with Kentish rag-stone, beaten down and mixed with sharp gravel and lime screenings, in the proportion of one of lime to five of gravel, and sills of beech, elm, or fir, 12 inches square, to be laid upon the pile-heads in a direction transverse to the foundations, and spiked down with 18-inch jagged iron spikes. The spaces between the sills—the extremities excepted—to be filled in with brickwork set in mortar, the outer spaces with square blocks of stone. Other sills to be laid across the lower ones at right angles to them, of the same material and size, and spiked down as before, the spaces to be filled in with stone set in mortar, and the whole covered with 6-inch beech, elm, or fir, bedded in mortar, well fitted, close-jointed, and spiked down with 12-inch jagged spikes three-quarters of an inch diameter. This forms the platform.

Round the three sides of the abutments, and round each pier, sheet-piling to be driven not less than 12 feet below the level of the platforms; the abutment piles to be of beech, elm, or fir, 6 inches square, and those for the piers to be of fir, 12 inches square, to be ploughed and tongued on the edges, and driven perfectly close, and connected with half timber fir waleings, bolted to the piles. The sheet-piles to be shod and hooped with iron.

Similar foundations to be prepared for the stairs by the abutments, but only one tier of sills required.

The masonry of the abutments from the platform to the springing of the arch to be built of ashlar, from 15 inches to 24 inches thick each course in front, and the beds to incline backwards parallel to the inclination of the platform. The exterior stones to be of granite to within 3 feet of the springing of the arch, the interior stone to be half Bramley Fall, and the remainder Painshaw, or equally good. The masonry to be formed of headers and stretchers alternately; the headers to average 5½ feet long and 3 feet wide, but none to be less than 4½ feet by 2 feet 3 inches. The stretchers to average 5 feet long and 3 feet wide, but none to be less than 4 feet by 2 feet 3 inches.

The backing to be laid in courses of headers and stretchers alternately, the headers being opposite to the stretchers in front, and of a suitable size, so that the whole of the masonry, both exterior and interior, shall be completely solid and bonded together, and double joggles to be used where required; the upper bed of each course to be dressed off smooth and even before the next course is laid. The whole of the exterior stone to be smooth, and fine hammer-dressed on the face.

The masonry of the piers up to the course next to the springing of the arches to be built of ashlar in horizontal courses from 15 inches to 25 inches thick. The exterior stone for 5½ feet inwards to be of granite, the interior the same as in the abutments; the arrangement of the masonry to be the same also.

Four sets of centres are required, each centre to consist of eight ribs properly braced together; to be composed of the best Baltic fir, except the springing pieces, which are to be of elm, and the striking wedges of oak, cased with copper one-tenth of an inch thick on the upper and lower sides, and greased before put into their places.

The arches to be semi-ellipses, the centre arch 152 feet span in the clear, and 29 feet 6 inches rise; the voussoirs to be 4 feet 9 inches deep at the crown, and 10 feet at the springing. The two next arches to be 140 feet span each, and 27 feet 6 inches rise; the voussoirs at the crown 4 feet 7 inches deep, and 9 feet at the springing. The two side arches to be 130 feet span each, and 24 feet 6 inches rise; the voussoirs at the crown 4 feet 6 inches deep, and 8 feet 6 inches at the springing. The whole of the arch-stones to be headers, except otherwise allowed by the engineer, and to be 18 inches thick at the intrados, and to increase according to the radius of curvature to the extrados, and none to be less than 2 feet 6 inches wide, and none to overlap at the joints less than 15 inches. The length of the voussoirs to increase when the inverted arches on the piers commence, according to drawing. The arch-stones to be dressed perfectly smooth and straight on the beds, sides, and faces, without any deficiency. The faces and soffits to be fine-dressed as before described. The extrados to be rough hammer-dressed, except when the inverted arches join, and there smooth-dressed, so as to bear solidly in every part. The whole of the arches to be of the best granite, properly bedded and jointed in mortar.

The spandrils over the piers to be of solid masonry in horizontal courses, corresponding in thickness to the back part of the arch-stones at their respective places, and to be of granite.

The inverted arches over the piers to rest on the solid spandrils, and accurately fitted to them, and to be 6 feet deep in the middle for the two centre piers, and 5 feet deep for the two side piers, and to be of the best granite, and set in fine mortar. A circular opening, 18 inches diameter, to be left through the centre of each pier, and through the solid spandril and inverted arch, down to below the level of low-water mark, and to communicate with the river, for the drainage of the roadway.

The spandril walls to be 5 feet thick, the courses to be laid headers and stretchers alternately, the headers not less than 2 feet 6 inches wide in the face, and not less than 3 feet 6 inches long. The stretchers not to be longer than 5 feet, nor less than 2 feet 6 inches broad on an average. The cap-stones on the point of the piers to be secured to the facia course below by 6-inch square stone dowels of the best granite.

A rectangular buttress is to be built over each pier and abutment, the outside to be faced with granite, and to extend to a depth inwards of at least 3 feet 6 inches; the faces, beds, and joints to be properly dressed and secured to the course below with stone dowels.

The outside of the abutments and wing-walls above the springing of the arches to be faced with granite, and to be not less than 3 feet 6 inches deep on an average.

The whole of the joints on the back of the arches and inverted arches to be well cleared out, and any opening found to be filled with grout, and afterwards pointed with Roman cement, and the whole surface of the arches between the termination of the inner spandril walls on each side of the crown of the arches to be covered with a coating of Roman cement of the best quality. The interior spandril walls to be of the best well-burnt grey stock bricks, laid flush in mortar consisting of three parts sharp river sand to one part of well-burnt lime; the interior mortar to consist of four parts sand to one part lime. These walls to be six in number over each pier, and to extend from arch to arch, and to be 2 feet 3 inches thick. On the top are to be stone corbels 18 inches deep, projecting over not less than 12 inches.

The arches and spandril walls being brought up to the level of

the roadway, the whole surface of the bridge is to be covered with a bed of sound, tough, well-beaten clay, 15 inches thick, so as to be perfectly impervious to water. Over the clay is to be 3 inches of fine sand, then 12 inches of fine flint stones, no stone to be larger than 2 inches in diameter, and the whole to be rolled. The foot pavement to be of granite stones, 7 feet 6 inches long, 8 inches thick, and 3 feet or upwards wide, one end to be bedded on the cornice, the other end to be supported on curb-stones not less than 4 feet long, 9 inches wide, and 12 inches deep, set edgeways, of the best granite, properly jointed and set in mortar, the intermediate spaces to be filled with fine gravel or sand. Along the front of the curb-stones are to be gutters paved with granite pitching paving, 9 inches deep for a width of 5 feet 6 inches from the outside of the foot paving. The roadway is to be curved 6 inches in its transverse direction, and the clay and pavement is to incline towards the gutters.

The cornice and parapet to be of the best granite, finely dressed and jointed; none of the stones to be less than 4 feet 6 inches long, bonded and dowelled. The coping to be dowelled at every joint by a projecting dowel, 2 inches square, fitted into an equal recess in the adjacent stone.

The approaches to be formed of solid embankments and arches where the height will admit; the former to be supported on the sides with brick retaining walls, and the piers of the latter to be founded 6 feet below high-water mark, the retaining walls to be 3 feet below this mark. The arches to be semi-circular, 16 feet span, and 18 inches deep at the crown.

The contract concludes with a most elaborate and carefully drawn covenant between the committee and the contractors.

In Fig. 85 we present a perspective view of one of the arches of this magnificent bridge, which was commenced on the 15th of March, 1824, and opened to the public on the 1st of August, 1831. The bridge contains 120,000 tons of stone, and rests upon 2,092 piles, 20 feet long. The total cost, including the contractor's estimate, the purchase of land, compensations, and law expenses, was £1,458,311 8s. 11¾d.

OPTICAL INSTRUMENTS.—XXVII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MODERN SYSTEMS OF MAGIC-LANTERN APPARATUS.

HAVING described the best methods of constructing the various elements of the magic lantern, I proceed to show the arrangement of the entire instrument under its various modifications of form to meet the special requirements of the school-room, the lecture-theatre, and dioramic exhibition.

The School System.—It is very important that the schoolmaster should be provided with an efficient instrument, that could be brought into immediate use for the exhibition of geographical and historical illustrations, and should occupy the least possible space when not in actual service. Such an arrangement is shown in Fig. 133, arranged for work, with its slide-tray in front. The body is made of japanned tin in an L-shaped form, to allow of its square chimney being packed away inside the body. The source of light is the hydrocarbon lamp of the form shown in Fig. 88, page 324, Vol. III. of THE TECHNICAL EDUCATOR, supported on the clamp-rod and sliding-floor shown in Figs. 110 and 111 of Vol. IV. As this lantern is intended for the exhibition of photographs by a weak light, my optical part consists of *a short-focussed condenser* and a *single* achromatic combination power, as a double combination portrait-lens (so useful for lime-light lanterns) absorbs too much light when Argand burners (weak lights) are employed; and with this arrangement I get a well-defined, flat, and brilliantly lighted picture up to 10 feet in diameter. The optical elements are fitted over the projecting limb of the body.

The slide-tray consists of three compartments, 3½ inches "full" square, each being deep enough to hold twenty-five photographic lantern-slides. The sides of these compartments are open, to allow of the finger and thumb seizing the slides. One compartment is left vacant, to allow of the arrangement being used in the following manner:—*The frame* is tunnelled and long enough to hold three slides in a row; in the centre portion there is a 3-inch circular aperture, which corresponds with the axis of the optical parts. One slide is pushed in, then a second, to bring No. 1 central; when this has been shown, a third is inserted, which brings No. 2 central, and No. 1 to the opposite end of the frame; this is now removed and placed in the vacant compartment of the slide-tray; when twenty-five slides have been shown, the empty compartment has been filled up, and the middle one emptied. In the same way this receives the slides as used from the last compartment; and when all have been shown a cover is dropped over to pack and protect them from meddlesome hands. The slide-frame was contrived by Mr. J. T. Taylor; the slide-tray is an arrangement of my own, being a modification of my slide cabinet, presently described. The slide-tray packs inside the square chimney, and as this again packs inside the body of the lantern, the whole may be packed into a box which only measures 13 inches long by 9 inches wide, and 9 inches high. The lid of the box is hinged, and by means of two notched rods may be set at any angle, so as to allow of the box being used as a stand, should it be necessary to "cock the lantern" to get it adjusted to the screen.

The screen is made of seamless cotton surfaced with flexible whitewash, which presents a perfectly opaque white ground, admirably adapted for showing lantern views in the most perfect manner; this is mounted in a case after the manner of a wall-map, so that it can be pulled down or up out of the way in a moment. The lamp may be made to occupy a permanent place for illuminating the master's desk for ordinary use in a school-room, and the lantern may be fitted and the screen

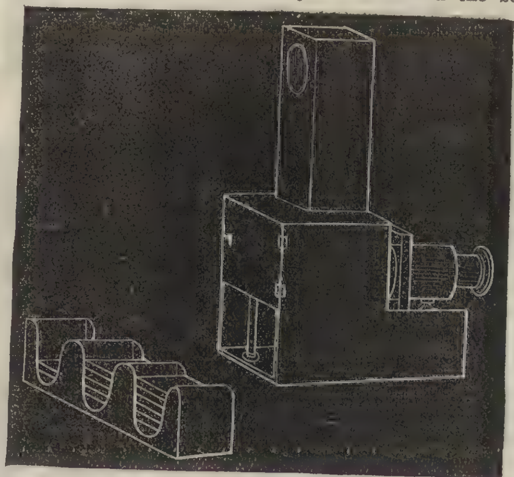


Fig. 133.—SCHOOL LANTERN AND SLIDE-TRAY.

pulled down when wanted in less than five minutes. In such case the desk should be placed at such a distance from the wall that the disc of light from the lantern just fills the screen.

The Photographer's System is similar to the lantern just described, but the stage, front tube, and power are removable, and may be used as a tubular metal camera for taking the negatives from which to produce transparent positives for our lantern exhibitions. It is then fitted with three double backs and a focussing glass, together with a table-top that folds to the same size as the back, which allows of the photographer taking stereoscopic as well as single views. The size of the negatives are circles 3 inches in diameter, on glasses 3½ square. This camera, with its appliances, packs into a small leather case, and with a folding or alpenstock tripod forms a very convenient travelling companion. This lantern can be fitted with a single stereoscopic lens for the Argand burner, or a quarter-plate lens if the oxy-spirit, oxy-house-gas, or oxy-hydrogen jets, or the magnesium lamps previously described, are to be used for producing transparent positives for the lantern, or enlargements on paper.

The Demonstrating System.—This lantern consists of a well-seasoned mahogany body* fitted with a flat dome of japanned tin, the convertible jet described and figured at pages 188 and 189, Vol. III. of THE TECHNICAL EDUCATOR, and a short-

* The oldest material attainable—preferably old dining-table tops, showy pattern in the wood being rather objectionable than otherwise.

focussed condenser, double achromatic combination, that is separable for a long-focussed arrangement, mounted to the stage, as shown in Fig. 130, page 334. This lantern is shown mounted on a lecture-room stand, which admits of every possible adjustment for optical demonstrations, in Fig. 134. It may be mounted single or in pairs for dissolving views, as shown in Fig. 135, where the slide cabinet and the packing-case form the stand; or if required for the electric light it may be mounted on a gallery supported on four brass pillars, as shown in Fig. 136, to allow of the tall regulator being adjusted within it.

The Slide Cabinet.—This I have arranged with the view of keeping all the slides required for any given lecture in methodical order; further, that a wrong slide can never be taken by mistake while working in a darkened room; that the slides should be repacked as used; that they could never be exposed to meddlesome hands, and could be put under lock and key the moment a lecture is over. The arrangement is simple, and the working will be readily understood by aid of the annexed diagram (Fig.137). The cabinet is divided into three compartments, and is fitted with two hinged doors, A and B, and two sliding panels, C and D; the compartments 1 and 3 are closed, with fixed ends E and F. Compartments 2 and 3 are filled with framed slides measuring 7 by 4½ in., arranged in order ready for use. In commencing, the doors A and B are turned back so as to display the first pile of slides in 2, and the empty compartment 1. The top slide is taken off the pile in 2, put in the stage by the exhibitor standing on the right-hand side of the lantern, and is withdrawn by his assistant on the left-hand side, who places it in the empty compartment 1, and so on. When all the slides in 2 have been shown, that compartment will of course be empty, and 1 full. The sliding panel C is then drawn back to expose the second pile of slides in 3, and D is drawn back to make a receptacle for the slides as they are passed through the lantern from the compartment 3. It will be seen that the piles of slides can never be knocked over, as each compartment must always be backed, and it is impossible to take a slide from the wrong pile. At the end of a lecture the panels are drawn back and the doors closed. On the following day, it is only necessary to return the slides in reverse order to their original compartments, and all is ready for the next lecture. This arrangement was described and exhibited at my second lecture before the Society of Arts, and, with my entire "system of apparatus," received the honour of admission to the Educational Department of the International Exhibition of 1870.

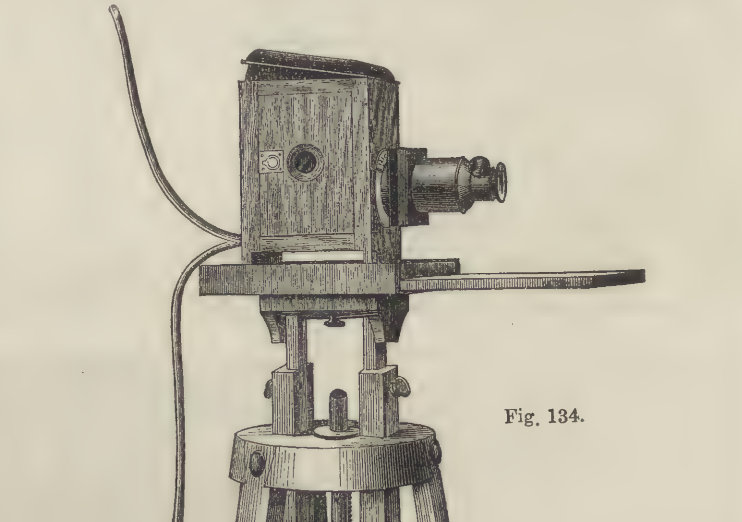


Fig. 134.

If the lantern is used with a 7-foot screen, the cabinet placed on the packing-case raises it so that the nozzle is central with the screen. If used with a 10-foot screen, then the cabinet is raised on a shell frame, that is made to pack outside the cabinet, as shown in Fig. 135, the nozzle in this case being also brought central with the screen. Both lantern, slide cabinet, and its shell pack away in a box 18 by 16 inches and 18 inches high.

Portable Drawing-room Screen.—This is also made of seamless cotton with an opaque white surface; it is 7½ feet square, mounted on a lath and roller which stows into a packing-case 8 feet long by 5 inches square, as shown in Fig. 138. Beneath this case two pieces, that together correspond with its length and breadth, are pivoted so that they can be turned at right angles to the case, and so form a firm base on which to fix in sockets two uprights, on which the lath is clamped, and then the screen is unrolled, as shown in Fig. 139. This can be unpacked and packed in a few minutes, placed in any convenient position at the moment wanted, and removed out of the way as soon as done with—a matter of importance for drawing-room exhibitions, as it dispenses with the removal of wall-pictures, furniture, etc. The height just allows of the frame being fitted together conveniently when the operator stands upon a chair.

Portable Lecture-room Screen.—This is 10 feet square, the largest size of *seamless* cotton attainable; it is mounted on a lath and roller, which slides into a long tubular case. To raise it against a wall, two long struts are provided, which for the sake of portability are hinged at their centres, but can be made rigid when placed at full length by means of bolts. The ends are cut at an angle, so as to fit wall and floor; when each strut is inclined against a wall, the lower ends are fixed to the floor by "stage screws" fitting in slots, the upper ends are fitted with small pulley-wheels, and the screen is pulled up by cords passing over them. These struts pack into a small case.

It will be observed that every provision is made in this *Demonstrating System*, not only for all the necessary apparatus being packed in the smallest possible compass for the con-

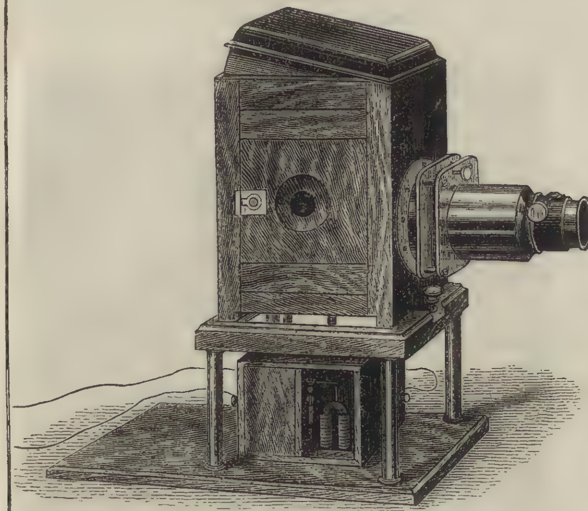


Fig. 136.

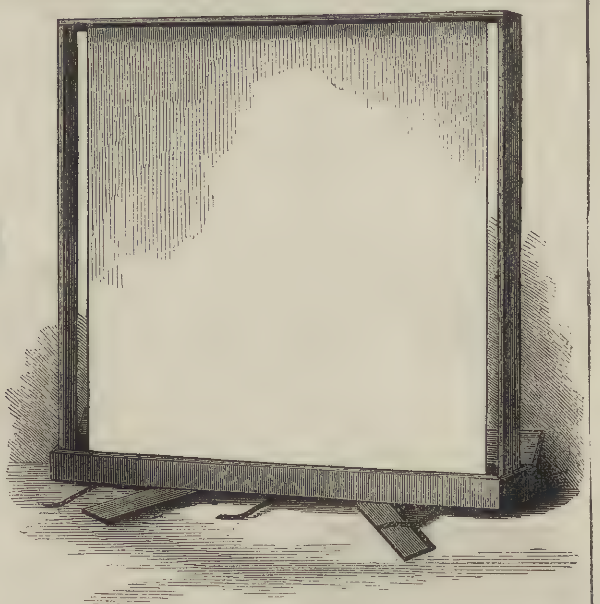


Fig. 139.

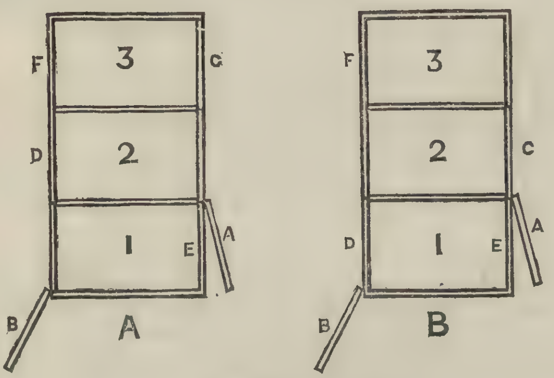


Fig. 137.

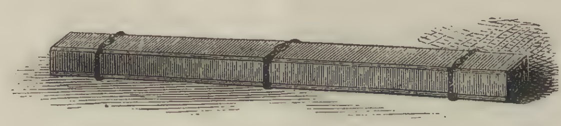


Fig. 138.

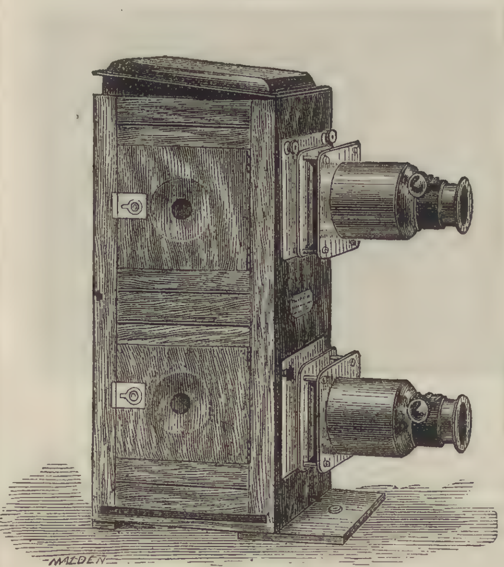


Fig. 141.

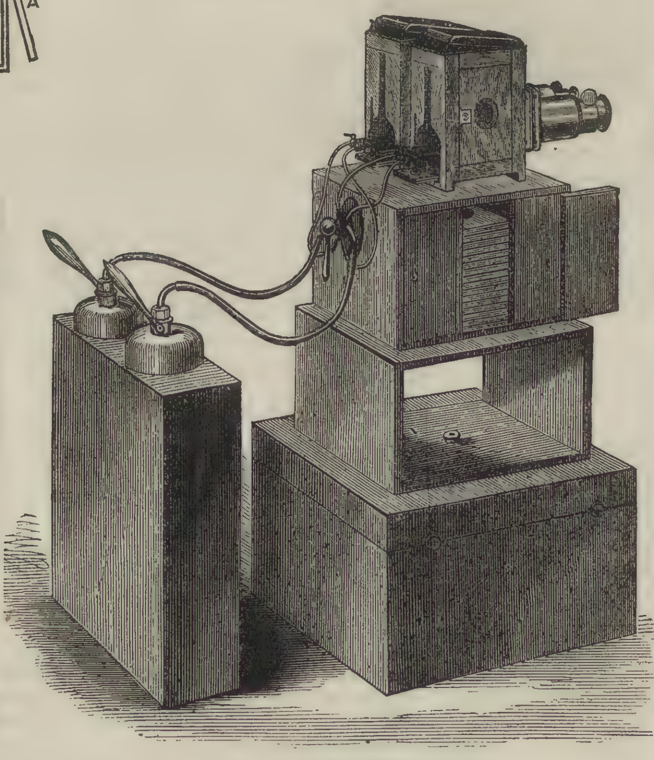


Fig. 135.

venience of travelling lecturers, but also to render them as independent as possible of all the ordinary obstacles that present themselves in a strange place, and with persons unconversant with their requirements.

Transparent Screen.—Under certain circumstances it is convenient to place the screen *between* the audience and the lantern, but the objection to this arrangement is that a halo always surrounds the opening where the light issues from the nozzle of the lantern, which stares the audience in the face and mars the effect. Where two rooms are separated from each other by folding doors, the screen can be tacked to the framework; but if there is only a narrow door, leading from a passage, etc., then the screen should be stretched upon a jointed framework, and arranged as shown in Fig. 140. The screen may be made of thin cotton sheeting, but muslin is better: either should be sprinkled with water from a syringe beforehand, to fill up the interstices and make the surface more homogeneous and transparent. The sides of transparent screens should be folded into stout seams, which should be drilled with eyelet-holes at regular intervals, to allow of their being *laced* to the frame, as this method admits of greater freedom for the even adjustment of the surface. In this case the screens are folded up, when packed, and the framework occupies a very small space.

The Dioramic System is intended not merely for the production of what are termed *dissolving views*—that is, the gradual fading of one view into another—but fine "effects" of various kinds, such as lightning flashing over a stormy sea, fire and smoke rolling from a volcano, burning buildings, etc.; snow falling over a winter landscape, waterfalls, torrents, balloons rising, demons descending, animals springing on their prey, etc. In Argand lanterns the "dissolving" is effected by combed fans, which, by various mechanical arrangements, obscure one nozzle as the other is gradually opened, and also provide for both nozzles being exposed simultaneously; but when the oxy-calcium or oxy-hydrogen apparatus is employed the dissolving effects should be produced by "gas-dissolvers," as this method not only economises one or both gases, but gives the exhibitor greater control over the effect thereby produced.

Fig. 140.

In Fig. 135, the method of arranging two lanterns side by side is shown; in this case the two nozzles must be inclined at such an angle to each other that their respective discs *exactly* coincide with each other. This adjustment, I find, is more quickly effected by means of Λ slots cut in a brass plate, that is made to slide in a dovetail fitting; both lanterns are pivoted in front on clamp-screws, and a pin is fixed to the back inner side of each lantern; these drop into the respective right and left hand slots of the Λ; on pushing the Λ slots forward, each lantern is forced outwards to exactly the same extent, till their optical axes correspond for any given distance.

The most convenient arrangement is that where, instead of two lanterns, the jets and optical systems are placed one over the other, as it is the only arrangement that allows of the exhibitor managing a dioramic lantern single-handed. This arrangement is sometimes termed the *bi-unial lantern*, but it has been brought to the greatest state of perfection in what is now known as the *Highley-Malden dioramic lantern*, as the improvement of the lantern for an educational weapon has been the hobby of Mr. Malden (travelling lecturer to the Polytechnic) and myself for many years past. This instrument is shown in Fig. 141, and is that now adopted at the Polytechnic Institution for their provincial entertainments, as their old-fashioned cumbrous apparatus entailed heavy charges for carriage, fixing, and removing, without any advantage as to optical superiority.

It consists of a mahogany body fitted with flat dome, a pair of "convertible jets" mounted on "clamp rods," the lower rod being attached to a sliding wooden slab, the upper rod to a sliding tin tray, made double to allow air to pass between its upper and under surface (as it stands immediately over the lower jet), and narrow to allow air to pass freely from the

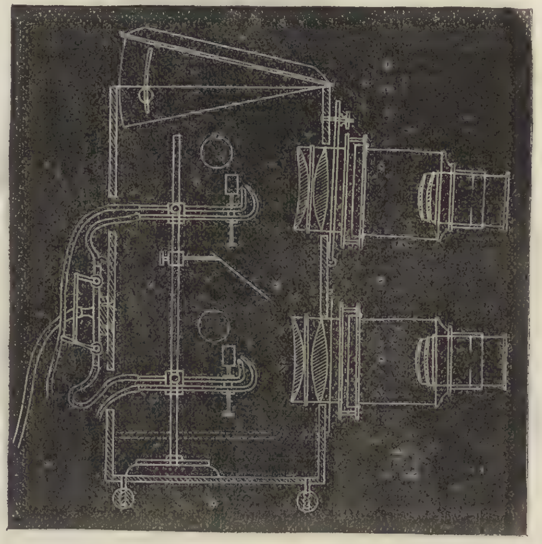


Fig. 142.

lower to the upper part of the lantern. The optical system consists of short-focussed condensers, double combination achromatic powers, mounted as shown at Fig. 121, page 312 of the present volume, with the exception that the upper stage is mounted on a hinged flange-plate to allow of the axis of the upper optical system being inclined and made to coincide with that of the lower one, the adjustment being effected by a spring and counteracting screw-heads. The internal arrangement will be understood by aid of Fig. 142, though it does not quite represent what I have described in regard to the jet-rods. The gas-dissolver may be a two-way-tap if the oxy-spirit or oxy-house-gas jet is employed, but for oxy-hydrogen jets the most perfect arrangement is that contrived by Mr. Malden, shown in Fig. 143, which I have further improved on so as to bring it into a single and very compact four-way-cock worked by a single lever arm, shown at the back of the slide cabinet in Fig. 135, but which does not convey the notion of construction so

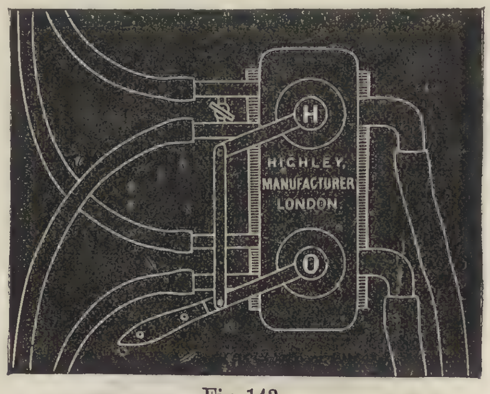


Fig. 143.

well as Fig. 143. On turning the tap the oxygen may be quite turned off, but the hydrogen is only cut down to a point, that ensures that gas being kept constantly alight. By turning the tap half-way both pictures are equally illuminated, or by playing with the tap while the exhibitor observes the screen, the best results attainable may be secured by the proper balance of light between the two slides, when producing "effects" by super-position; as in the case of *bright* smoke on a *dark* view,

in the subject of the "Steamer leaving the port of Alexandria." The hydrogen is admitted by the upper large tube, and is then divided by the tap H (Fig. 143), from whence it is carried by short flexible tubes to the hydrogen tap of each jet, the balance of gas being effected by the small tap placed between the two exit-pipes. The oxygen is admitted by the lower large tube, and is divided by the tap O, both taps being made to work in unison by the connecting bar and lever-arm. This arrangement also entails a considerable saving of both gases.

Flashing fans are arranged so as to *instantly* cut off one picture and throw another on to the screen, as, for instance, when a tiger is depicted *about* to spring upon its pursuers in one view, and *then* on the body of its victim in the next. An "effect" is then said to be "flashed on." It is very advantageous to employ a third lantern when "effects" are to be produced in public, and in such cases it should be of the true *phantasmagoria* construction, that is to say, it should be made to run on a tramway to and from the screen, and simultaneously, by means of a lever and roller working on an inclined bar between the trams, not only automatically adjust the focus, but also reduce or enlarge the aperture of an "iris diaphragm" placed in front of the power, shown in Fig. 144, which opens or shuts by the upward push or downward drag of the two rods; as otherwise the picture would be too intensely brilliant at the very moment it ought to be of an opposite character—that is to say, when a figure is supposed to appear at a great distance off because it is of small size, when consequently the lantern must be near to the screen, and, according to the law of inverse square, the illumination at its brightest. The reverse, of course, obtains when the object appears to be near to the spectator, because larger, and the light is then most distributed over the screen because the lantern is withdrawn from it.

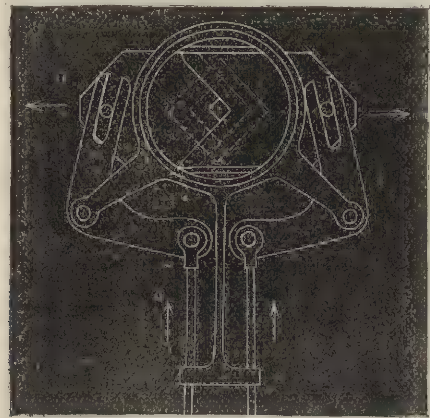


Fig. 144.

In concluding this series of articles on "Optical Instruments," I may state that I have selected those subjects which are not fully treated in a technical manner according to the latest experiences in existing works, rather than compile matter which may be found in English or foreign books on optics.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XLI.—THE EARL OF ROSSE, K.P., F.R.S.—GREAT REFLECTING TELESCOPES (*continued*).

The magnificent instrument described in our preceding paper rendered valuable services to astronomy by the light which it threw upon the structure of the nebular part of the universe. It was about Christmas, 1845, that the great six-feet reflector was first directed to the wonderful nebula in Orion; and who shall tell the anxiety with which the result of that gaze was watched? Did nebulous fluid exist in space or not? That was the question to be solved. And solved it was. That fleecy cloud was *not* a vapour; it consisted of stars! Worlds, millions upon millions—who shall say not peopled with intelligent existences? This gigantic telescope is, as compared with the human eye, as 130,000 to 1; it has a penetrating power of 500; and can render visible stars whose light would require 60,000 years to reach the earth!

Many nebulæ, which had hitherto resisted all attempts to resolve them with instruments of inferior power, have been found to consist wholly of stars. Others exhibit peculiarities of structure wholly unexpected. Thus, former observers suggested the probability of the nebula No. 51 in Messier's catalogue being a vast sidereal system, identical in structure with a smaller one in its immediate vicinity, and to which it offered a striking analogy. The telescope of Lord Rosse has, however, destroyed this interesting surmise, by showing the nebula to be of a totally different structure—to be, in fact, composed of a series of spiral convolutions, arranged with remarkable regularity; and a connection has also been traced, by means of these spirals, between the nebula and its companion.

In 1862 Lord Rosse communicated to the Royal Society further observations upon the nebulæ, with practical details relating to the construction of large telescopes. These are followed by a selection from the observations made during a period of six years, accompanied by drawings of the more remarkable objects. The principal results seem to be a large addition to the list of nebulæ with curved and spiral branches, and many new double and multiple nebulæ. A variety of objects have also been pointed out upon which the labour of a careful scrutiny will probably be amply repaid, with a similar instrument, even in this climate.

Spectral analysis has been used by our countrymen to scrutinise not only planets and stars, but even to reveal the constitution of the nebulæ, those mysterious masses out of which it has been thought that new suns and planets might be evolved—nursing mothers of the stars. For a time, indeed, the resolution of the nebulæ by the giant mirror of Lord Rosse afforded ground for opposing the speculation of Herschel and the reasoning of Laplace, which required for their very starting-point the admission of the existence of their gaseous expansions, with or without points, or centres of incipient condensation, with or without marks of internal movement. The results of the spectral analysis of stars have, however, restored the balance. The nebulæ are, indeed, in some instances, found to have stellar points; but they are not stars. The whole resembles an enormous mass of luminous gas, with an interrupted spectrum of three lines, probably agreeing with nitrogen, hydrogen, and a substance at present unknown. (Professor John Phillips, F.R.S.)

A question, however, arises as to whether Mr. Huggins's discovery by the spectroscope really overthrew the hypothesis of Dr. Herschel. It would appear not. Dr. Herschel found some of the nebulæ to consist of clusters of telescopic stars, and others (among them the nebula of Orion) appeared as mere luminous spots, or cloudy masses of vapour, of different forms, which it was considered might be gaseous matter in the process of formation into suns and their attendant planets. Herschel was of opinion that these luminous spots, when viewed through glasses of higher powers, would be resolvable into masses of nebulous stars of countless numbers. Lord Rosse subsequently examined Orion with his powerful telescope, and found the nebula *resolvable*, and thus the hypothesis of Herschel was *à fortiori* confirmed and *de facto* established. In using the term "stars," Herschel doubtless intended it to be accepted in the general sense—viz., luminous bodies—and not as commonly used by English writers to denote fixed stars of the usual density. If we assume this to be the definition of the term used, we shall find that the recent discoveries of Mr. Huggins not only do not refute, but actually confirm the assertion made by Lord Rosse, the investigations of Mr. Huggins having, as already stated, proved the nebulæ to be masses of incandescent gas, or, in other words, dense clusters of luminous cloudy bodies, or gaseous stars.

Investigations into the nature of the nebulæ have tended to confirm the accuracy of the views of Laplace, who held that the sun and planets were formed out of a great nebula, which by condensation separated into rings, and these rings finally collapsed into stars. The zodiacal light is supposed to be the remains of the great nebula out of which the solar system was constructed, and the condensed matter rained into the sun, and there burnt, is supposed to be the origin of the sun's light and heat. One question, however, still remains unsolved. In what way did the nebulæ originate? Is each nebulous atom formed out of the other by the action of light, and the aggregation of still minuter particles, in the same way in which a nebula, by its condensation, goes to form a planetary system?

We are induced, by way of summary, to pursue the subject

still further, as illustrated with peculiar force in the *Saturday Review*, in a paper wherein the negative results are somewhat strongly designated as "the *break down* of the nebular hypothesis, under the disclosure of Rosse's telescope—a remarkable instance of a promising speculation prematurely cut short." It is explained as follows by Sir Henry Holland (President of the Royal Institution):—

"The third great result from Lord Rosse's telescope—viz., the resolution into stars of many nebulæ before unresolved—bears closely on the question so much agitated of late, as to the existence of a self-luminous nebular matter diffused in different parts of space, and forming the material out of which worlds are aggregated and systems of stars are brought into being. This theory, sanctioned by eminent names, and plausible at least in its application to our own planetary system, found support in the aspect of such unresolved nebulous lights in the remote heavens. The simple fact that the progressive increase of telescopic power has, in the same ratio, disclosed to us these luminous masses as clusters of innumerable stars, must be considered a cogent, though not a decisive, argument against it; the nebulæ still not analysed presenting the same aspect as those which have been thus recently resolved, and perhaps awaiting only a higher power to afford the same results. Furthermore, it may reasonably be doubted whether nebulous matter, yet uncondensed into stars, could from distances such as these radiate light apparently equal in intensity to that of nebulæ known to be composed entirely of stars. The whole question, by the very terms of it, will be felt as one incapable at present of any complete solution. But the negative, upon the modern nebular theory, has been strengthened, and those bold speculations placed in abeyance which dealt with the consolidation of worlds as if it were a matter of familiar observation, and within the compass and calculation of ordinary science. We acknowledge ourselves of the number of those who hold this to be a salutary check, and in accordance with the true interests and legitimate course of physical inquiry."

A new difficulty has, however, arisen from these vast successes in telescopic construction. To ensure the best performances of a telescope, not only should there be a cloudless sky, but a perfectly quiescent state of the whole atmosphere—a most serene and quiet air, and this is indispensable for high magnifying powers; yet so rarely is this state of the air to be found at the sea-level, that Lord Rosse assures us that whole years have passed away without affording him, among an abundance of clear nights, one of such accurately defining quality as to enable him to use the higher magnifying powers of his great reflecting telescope to any advantage. And this is a difficulty which continually increases with the size and excellence of the telescopes employed.

The Earl of Rosse, the framer of the great reflecting telescope, died at Birr Castle, on the 31st of October, 1867. Within a period of ten days died Sir James South, another celebrated worker in the same direction; and Lord Wrottesley, whose high astronomical attainments are also well known.

GREAT MANUFACTURES OF LITTLE THINGS.—XVII.

SMALL PLATED WARES AND ELECTRO-PLATING.

BY CHARLES HIBBS.

About the middle of the last century, the miners who worked in the silver and copper mines of Germany came upon a vein of glittering ore, different from anything they had previously observed, having all the brilliancy of silver, with a reddish tinge that seemed to betoken the presence of a yet more precious metal. As the lode was gradually laid open, the quantity seemed abundant enough to confer inexhaustible wealth upon the fortunate finders, and they gave themselves up to the wildest excitement at their good luck. Great was their disappointment to find that their new mineral treasure, so far from yielding virgin silver or gold in boundless profusion in the smelting furnace, only mocked their hopes by giving up, after innumerable trials and experiments, a nasty, brittle substance of a dirty-white colour, that went to dust under the hammer, and which the crucible would only reduce to a miserable grey ash. Thus baffled of their El Dorado, the miners, superstitious from time immemorial, easily came to think that some *diablerie* was at work, and whenever they found the villainous ore, bestowed upon it, along with their most supreme contempt, a name by which they had been used to distinguish the gnome or goblin of the mine, to whose evil influence they attributed this and all other of their misfortunes. Thus, the new metal came to be called "nickel"—*Anglicè*, "Old Nick—" and for a long time only turned up to be thrown aside with grudging toil and bitter disgust. At last, the celebrated Swedish chemist and mineralogist, Kronstadt, hearing of it, obtained some specimens which had been found in the mines of Helsingland, and subjected them to analysis. After five years of laborious investigation, he announced that he had discovered the hitherto enigmatical substance to be one of the elemental forms of matter, not capable of being resolved into any constituent parts, and classed it among the semi-metals. Thus heralded, it attracted the attention of men of science in various countries, who bestowed upon it an infinite degree of learned labour and research, all to no purpose. Richter, of Berlin, succeeded in reducing it to a state of chemical purity, but none could master its invincible repugnance to fusion, and its use in the arts was consequently out of the question. Not until the year 1827, or thereabouts, was it turned to any useful purpose, and then a German manufacturer, named Geitner, produced, after many trials, an alloy of nickel, zinc, and copper, beautifully white, and workable by the ordinary processes, to which he gave the name of *argentan*. Since then, the same three substances have been variously mingled, and given to the world under the different names of white copper, new silver, semi-argent, albata, German silver, and many others, the last quoted being that by which the alloy is most generally known. It bears a close resemblance to silver, is fine in texture, hard, and capable of a high degree of polish, and but for its greater liability to oxidisation, would serve most of the purposes of silver equally well. For plating purposes, however, it is the very best material now known, especially *electro*-plating, for which it furnishes an excellent base; and by its similarity of colour, conceals for a longer time than copper the effects of wear and tear upon its coat. The best quality of German silver is composed of forty parts of copper, and twenty parts each of zinc and nickel; and of this alloy, so lately introduced to the metallurgical arts, there are annually consumed from 1,200 to 1,500 tons. About 7,000 persons are employed in the German silver and plated trades in Birmingham, and about 5,000 in Sheffield.

As though to rebuke the self-complacency of this age of invention, it seldom happens that any new discovery is made and turned to account, without it afterwards appearing that the same thing was known to some semi-barbarous people of remote antiquity. The Chinese have more than once forestalled us in this manner, and it was destined that they should also steal a march upon us of several ages in this matter of the new white metal. Travellers who had penetrated the Flowery Land reported that they had seen gongs and other musical instruments native to the people, made of a metal closely resembling silver, but harder, and having peculiarly sonorous properties. They added that the composition of this metal was kept a profound secret, and that it was forbidden to export it under the severest penalties. It was called *packfong*, and for a long time all that was known of it in Europe was its curious name. At last, some small articles made of it found their way here as curiosities, and got into the hands of the scientific metallurgists, who soon penetrated its mystery. Dr. Fyfe, of Edinburgh, announced that upon analysis he had found its constituents to be—zinc 25·4, copper 40·4, nickel 31·9. In short, *packfong* was no other than German silver.

It is well known that when the introduction of the voltaic process caused a complete revolution in the plated trades, the genius of Elkington was the first to seize the opportunity, and carry it to an almost unparalleled commercial success. This success has been greatly due to the fact, that from the first he determined to use the new metal, German silver, in preference to copper, for the material of his wares. The difficulties he had to surmount cannot be easily estimated by those who are not familiar with the subject. In addition to the numerous vexations and baffling disappointments of the first stages of electro-plating, the capricious behaviour of the silver, which would sometimes only adhere in places, or not at all; sometimes lie on the work in the form of loose grey powder; sometimes come out brown, yellow, or piebald; sometimes appear covered with streaks and

nodules in most eccentric fashion; sometimes blister up and peel off altogether at the first touch of the burnisher, when an apparently firm and even coating had been, after infinite trouble, obtained: in addition to these, there were the difficulties of working the new metal, uncertain in its quality, strange to the artificer, and much less tractable at its best than the metal he had been accustomed to manipulate. It was extremely difficult at first to obtain a fixed quality of German silver. The three metals of which it was composed had each varying properties, and often contained foreign substances, which it was difficult to get rid of, such as lead, arsenic, or antimony, causing brittleness, and spoiling the colour. The nickel it was almost impossible to get pure, until a new method of refining it was discovered by Mr. Askin, a veterinary surgeon, and a student of chemistry. He was led to adopt a purely chemical method, instead of the ordeal by fire then in vogue. Mr. Askin dissolved the crude metal in acids, and precipitated the baser metals, so that the pure nickel was in a state of solution, afterwards to be precipitated in the form of oxide. The purest quality is essential for all three metals, in order to get a good malleable German silver, and even then, the inherent brittleness of the most important ingredient, the nickel, will often show itself at some critical stage of the manufacture in the shape of an ugly crack. Difficulties, however, only served to whet the resolves of the Messrs. Elkington, and in spite of the opposition of the trade, they persevered in the use of the new metal until they had conquered all its defects.

Having thus briefly introduced the new metal to the notice of the reader, we will proceed to describe the method of working it up into the small articles which adorn our tables, and serve our uses in so many ways. Let us suppose that the articles to be produced are spoons and forks. The first thing to be done is to cast the alloy into ingots of long flat shape, convenient for rolling, being careful that the three ingredient metals shall be thoroughly mixed, so as to produce a perfectly homogeneous mass. The "strip-caster," as he is termed, is bound to exercise great care in this respect, the whole success of the after operations depending greatly upon his skill and attention. The ingots, or "strips," are then rolled into plates, to a gauge corresponding to the thickest part of the spoons or forks that are to be made. The width of the plate will be equal to the length of those articles. It is then cut across with shears, which slice off little tapering strips in the manner of a nail-cutting machine, taking them from head to heel, and *vice versâ*, so as not to lose a scrap of the material. Being annealed thoroughly, they are next "cross rolled," which means spreading out a portion of the broad end to form the bowl, and a portion of the other end to form the handle of the spoon. Boys place them one by one under the rolls, and for the broad end it will require several rollings before the pieces are sufficiently flattened out. They are now in shape something like miniature malt shovels, and a stranger would suppose that they were made of iron, they being in tint and general appearance exactly like that metal in the forged state. The universal press now comes into operation, and a pair of cutting-out tools give the unshapely articles the perfect outline of a spoon, or fork, as the case may be. In this state they are turned into the "pickle," which, as we have explained in a former article, consists of diluted or weakened aquafortis, and whose office is to cleanse the metal from grease and other impurities, and to remove the "scale," which is the burnt outer surface caused by the several annealings. They will be of a dirty-brown colour when they come out of pickle, and a dip in the strong acid will restore their natural complexion of a dead white. The next process is planishing. German silver becomes hard by beating or rolling, and advantage is taken of this property to procure rigidity where it is wanted, viz., in the stem, by compressing that part between dies of plain surface, till the requisite degree of firmness is obtained. A filer now smoothes the flat of the stem on the under side, and puts in the trade-mark at a press, also smoothing a small portion of the bowl-part for the purpose of the next operation, which is stamping upon it the little projection which in trade *parlance* is called the "heel," and which seems to indicate the juncture of the bowl with the stem. There will also be a little swelling on the other end of the handle, called the "nib," and this is also struck on at this stage. Should the spoon or fork be of an ornamental pattern, such as the "lily," the "wheat-ear," and many others well known to retailers and the public, of course such pattern will have to be stamped on also; the parts being previously well smoothed to admit of a clean impression being made. The "rough-maker" now takes the article in hand, smooths off the burr left by the stamp, strikes up finally the under side, and bends down the little curve at the end of the handle over a block with a small wooden mallet; then strikes up the front of the stem, smoothes the edges, and bevels them. They then leave his hands for a while, and go to the "bowler," who domes up the broad end into the semblance of a bowl, with a press or stamp. Two or three blows will be requisite to make the concave deep enough, according to the size of the spoon: a soup-ladle would require eight or nine blows. The rough-maker now receives them again, strikes off the top edges of the bowls perfectly level, smoothes off all the sharp edges, and "sets" them, *i.e.*, bends them into graceful and uniform shape over a block, so that they may lie nicely in each other. He uses for this purpose mallets made of tin, boxwood, or horn, and compares his work with a model from time to time. When he has done with them, they are, in fact, perfect articles, and only require polishing and plating to fit them for sale.

The description just given would apply equally in the main to the manufacture of forks as to that of spoons; in fact, the same set of workmen would manipulate both, but there are some points on which the processes diverge. After being cut out by the cutting-tools, the next step in the manufacture of a fork would be the piercing—viz., cutting out the spaces between the "tines." The blank is, in the first place, cut a little larger than is necessary in order to leave room for a "get," or solid piece at the end of the prongs, which is retained during many of the subsequent processes for the purpose of maintaining the requisite rigidity to keep the article in shape. Thus, the spaces are not cut out right to the end, but stop short within about a quarter of an inch, the extreme end being left solid as at first. The cutting-out tools are of the usual fashion used in a press, with the exception that the upper tool is shaped longitudinally in the form of a wedge, the apex of which touches the fork-blank first in the middle. It has thus a gradual cutting action, something like that of a pair of scissors, and cuts out the piece rather by continuous pressure than by a sudden blow, thereby avoiding the danger of fracturing the metal. A line of little studs on the bottom die, close by the side of the slit, directs the workman where to place the blank to make the first cut, and for the second he places the slot just made on to the studs, and so on, ensuring equal distances between them. The article is set, filed, and stamped with the "get" still on, and it is cut off the last thing to allow of the prongs being pointed and filed up. A very beautiful method is practised at Elkington's and other manufacturers of best work, of putting solid silver points on the prongs of electro-plated forks. The points, about half an inch long, are neatly dovetailed into the German silver, soldered, dressed off, and plated all over, so that the joint is thereafter undiscoverable, and for all practical purposes the article is the same as a solid silver fork. There is no danger of the joint ever giving way, if well done.

At this stage the work is subjected to a careful examination, to see if any defects have appeared in the metal, and if the workmanship is good and true. A good spoon should be perfectly level on the top of the bowl, the edges even and regular, and the contour graceful and well balanced. If one side of the bowl is sounder or fuller than the other, it is said to have the *toothache*. The stem should be set straight with the bowl, and bent so that half-a-dozen spoons may lie nicely within each other. When all these points have been duly rectified, the articles are given into the hands of the polisher.

The *rationale* of all polishing is simply brightening by abrasion, or scratching of the surface, and the utmost that can be done is to make the scratches as fine as possible. A perfectly smooth surface it is impossible to obtain, as no medium can be employed but will remove something from the substance, and it must do so by attrition. The smoothest wash-leather, if used to rub up metallic surfaces, will become impregnated with the fine particles which it removes, and even the human hand, the best polishing medium known, will take up a very small portion of what it brightens, and waste it to that extent. Probably the brightening effect is due to the presence of the impalpable particles of fine dust which are always floating about in the atmosphere, settling upon everything, being

inhaled with the breath, and entering into the organisation of all things that live. Being parts rubbed off from the solid matter of the earth, this dust is simply grit, as much so as sand or gravel, and under the microscope would present the same characteristics. Therefore, the very highest polished surface is simply a series of scratches, the finer and more numerous they are the greater being the brilliancy attained.

Our spoons and forks, if they are to go forth to the world as German silver wares without disguise, will now receive their final touches, and be disposed of at once; in which case they will be first "bobbed" with fine sand on an ordinary buff-covered polishing wheel, and afterwards finished off with lime and rouge. The finishing bobs are made of a number of loose discs of cloth, placed close together, and threaded on the spindle like an old-fashioned mop on a mop-nail. They revolve at an enormous speed, and when the spoon or other article is pressed by the workman against the soft pad, dressed with grease and fine powder, it receives as high a polish as it is possible to give it. The colour and gloss are brought up afterwards to full perfection by "handing," *i.e.*, brisk rubbing with the palm of the hand.

If they are intended for plating, however, the polishing of the wares stops short at the first process, and they are sent down to be silvered, after having been bobbed with sand. Before entering upon a description of the present chemical method of plating, it will not be improper to advert briefly to the old process, by which the table ware of our grandmothers was honestly coated with a layer of the cleanly and respectable metal. We may premise that the base in those ante-German silver days was frequently iron, and among family relics may often be found a silvered spoon, the thick white coating of which has been eaten through in pin-holes or small streaks by the rust that is corrupting underneath. The method of plating them was in this wise :—The article was first immersed in a solution of zinc with some strong acid, generally smoking salts, which left a strongly adhesive film upon the surface. It was then dipped in a caldron of boiling tin and lead, acquiring a tolerable coating of this material, the surplus of which the workman threw off by vigorously swinging the article in a trough. When cooled, the roughnesses were taken off with a "smooth" or scraper, and it was ready to receive the silver. Holding it with convenient clams in his vice, the workman would lay upon it a piece of thin leaf-silver, cut roughly to the required outline, and would press it down with a hot soldering tool, or "doctor," till the tin underneath was melted, and the silver adhered. He would then serve the other side in similar fashion, pressing as much as he could conveniently all the interstices of the work, and making as good a joint as possible on the edge, where he would turn down the edges of the silver after trimming it off with a glazier's knife. This done, he would sprinkle resin over the surface, and turning to the hearth, would hold the article in the fire till the resin blazed, by which token he knew that there had been heat enough to run the solder. He had to be wary about exceeding this heat by even the slightest degree, or otherwise the thin silver would also melt, and run away into the fire. Then, while the work was still hot, he hasted to the bench, and rubbed down the plating with a handful of tow, working it well into all the hollows; after which treatment there was no fear of its coming off, nor could any indication be perceived that it was simply a veneered, and not a solid article. Even now, many articles of table ware are plated in this fashion, especially steel articles that are exposed to wear. Thus, the blade of a plated dessert-knife must be of steel, because German silver would not possess the requisite degree of rigidity and elasticity; if plated by the electro process, the plating would not be sound enough for wear, on account of the weak chemical affinity between the two metals; but the old process produces a good, sound, wearable article. The new method is by far the most beautiful, and the most suitable for general work, besides being the most scientifically interesting.

Electro-plating.—It will not be out of place, however, briefly to recount the points of interest in the development of this latest addition to our productive agencies. The discovery of Galvani that electricity could be evolved from substances by other means than friction—in fact, by simply placing two metals together—was undoubtedly the first step in the series of events which led to its birth. He supposed that the effect was due to simple contact, and that the subtle fluid was always being given out, though in quantities imperceptible to the senses, whenever two substances touched. Volta, who followed him, seemed to prove by his experiments that it was rather the result of a chemical action, the rushing together of particles having an affinity for each other into chemical combination, electricity being disengaged in the process. Thus, the air itself, charged with a powerful dissolvent, oxygen, ever tending to oxidise or rust any metal exposed to it, is continually producing electricity by forcing the particles of metal to combine with its own particles of oxygen. When two metals are brought into contact which have different degrees of affinity for oxygen, the violence of the oxidising action in the one and the weakness of it in the other will cause a current of electricity to set in between them, and by this means only does its presence become visible. The action of the air, however, at the best is only slow, and it requires a more powerful dissolvent to produce a current of electricity of any considerable force. Water will do better, but the best medium is some corrosive liquid that will disintegrate the particles of metal with great rapidity. Volta, therefore, instead of placing his metals one upon another, inserted between them a piece of cloth saturated with an acid, and connected the two metals with a bent wire touching both, such connection being necessary in order to induce the currents. The acid acting strongly upon the bottom plate, which was of zinc, and feebly upon the upper plate, which was of copper, caused a continual flow of electricity from the one to the other. He increased this by building up a series of plates, with saturated cloth between them, in proper order, and fixing the conducting wire to the top and bottom plates only, thus getting the accumulated electricity into one current; and this apparatus was known as the *voltaic pile.* It was soon perceived that as the only use of the cloth was to retain the liquid, the metals had better be immersed in it at once, and so came the construction of the trough battery which is now universally used. A pair of plates is suspended in the corrosive solution apart from each other, but connected with copper wires or bands at the upper edges; and intensity to any extent is produced by multiplying the number of troughs or cells, and establishing a connection between them. Sir Humphry Davy used a battery consisting of 2,000 cells, and with it he decomposed alkalies and earths that had hitherto defied the power of chemistry.

The difference between the electricity generated by the voltaic battery and that evolved by friction is that the former is much greater in *quantity*, and is also continuous; owing to this, it is capable of producing effects that are beyond the power of instantaneous electricity, not the least of which is that of decomposing compounds. During the progress of the many experiments that were made to ascertain the best form of battery, and the best liquids to use, the invention of Daniell's Constant Battery took place. It has been explained that success depends upon the violent action of the acid upon one plate and its feeble action on the other. Daniell's battery consisted of an interior cell of unglazed porcelain, placed in a larger cell of copper. The inner cell was filled with dilute sulphuric acid, and the outer one with a saturated solution of sulphate of copper. A rod of zinc was suspended in the acid, which acted strongly upon it, while the sulphate acted mildly upon the copper, the electrical influence passing, where the corrosive liquid could not, through the pores of the inner jar. Thus the necessary conditions were simply obtained. It was found, however, that by an indirect action, which we need not stop to explain, the electric current was setting free the particles of copper from the compound, and depositing them upon the metallic cylinder itself. Here was the first indication of electro-deposition. There was no thought at the time of turning the discovery to account, and the only thing done was to provide, by very simple means, for renewing the waste in the sulphate. For a detailed description of this process we refer our readers to a paper on "Voltaic Electricity" in THE POPULAR EDUCATOR, Vol. VI., page 8.

FARMING AND FARMING ECONOMY.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

XXII.—FARM BUILDINGS.

THERE are many kinds of farms differing in character from each other in the quality of their soils, the proportion of arable land to pasture, and in physical position.

1. *Pastoral Farms*, devoted to the breeding and rearing of

young animals. Sheep usually occupy the poorer and more exposed soils adapted to this purpose, while cattle are found upon the lower and richer lands. Such farms are usually very extensive, and occasionally occupy many thousand acres, and extend over several square miles. Such farms do not require buildings of a complex or expensive character, and where sheep alone are kept, mere "stells" are sufficient. These stells are of various forms, and consist of walls destitute of roofing, and so arranged as to protect the sheep from severe blasts of wind, and during storms of hail or sleet. In selecting a site for a stell a sheltered situation is desirable, and the simplest forms are circular, the circumference being broken in one or two places for the admission of the sheep. A stack of hay, securely railed off, often occupies the centre of this enclosure, and the insides of the wall may be fitted up with racks for supplying hay in stormy weather. Two parallel walls, with a third wall connecting them at their centres, and at right angles to their direction, is a useful form of stell. These primitive farm-buildings, if so they may be termed, can, by a small additional outlay, be rendered both more efficient and sightly. Thus, a double wall, with a plantation between the two walls, is an admirable plan, the shelter in such stells being very perfect. The diameter of the internal circle will be about 18 yards, but varies according to the flock. A still more complicated form, and one calculated to give shelter from every wind, is of the form shown in Fig. 1. The centre is planted, and the walls are so arranged that four capacious bays give shelter to the sheep.

Carse Farms are situated in low, flat, clay districts, as in the Carse of Gowrie, in Perthshire. The retentive nature of the land adapts such farms for corn rather than live stock. The buildings are therefore limited to the accommodation of the crops and the means of preparing them for market, together with yards for a few "straw beasts" and milch cows.

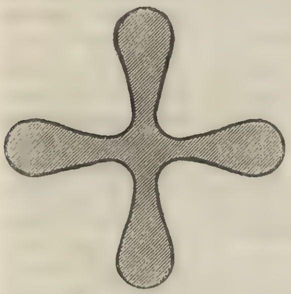


Fig. 1.

Dairy Farms occur in districts where good pastures abound; and buildings suitable for the manufacture of butter and cheese, together with accommodation for a large stock of cows, form the principal and most characteristic features.

Suburban Farms are usually cropped with a view to supplying the neighbouring town with various kinds of vegetable produce and milk. Straw also commands a high price: we shall therefore find the buildings specially adapted to cow-keeping, while the most economical use of straw is obtained by the construction of liquid manure tanks. In other respects the buildings may resemble those on the farms next to be considered.

Mixed Husbandry Farms.—On these the most complex arrangement of buildings is required, and we shall therefore consider the rules that should guide us in the selection of the site and the designing of such farm-buildings.

Farm-buildings for mixed husbandry farms are needed for four important objects: 1st, for the comfort of live stock; 2nd, for the preservation and accumulation of manure; 3rd, for the preparation and storing of grain; and 4th, for the stores of cake, artificial manures, wool, and other substances required on farms.

With regard to the position or site of farm-buildings, we must consider the size of the farm; the relative position and proportion between arable and pasture land; the form of the farm; shelter; the inclination of the ground; the water-supply; and the proximity of good roads. As a general principle, the nearer we can have the homestead in the centre of the farm the better, always deviating according to the predominance of arable land, where, of course, the bulk of the work is conducted. On very large farms it is a question whether the homestead should consist of one central set of buildings or be divided into two or more smaller sets, placed conveniently for the surrounding land. A good rule is, never, if possible, to be obliged to cart the produce of fields, or manure, further than one mile. When this distance is exceeded it is much the best plan to adopt the system of field-barns and straw-yards, so as to diminish the cost of carting. There are advantages in a single and central homestead. The whole is under the eye of a master; machinery and power is concentrated; labour can be more comfortably and economically carried out; and a greater amount of comfort and warmth is obtained for the stock. The introduction of portable threshing machines has done much for the scattered buildings plan, and on large farms this system has also its advantages. In harvest, for instance, it is a great comfort to stack the corn in the fields, and, unless the farm is provided with a rick-yard of special merits, there is little doubt the corn comes into condition sooner in the open field. If, then, we build stacks in the field, it will be as well to thresh them there; to tread down the straw by means of cattle in yards at the same place; to cart the turnips grown in the land adjoining; or to provide other foods, and make manure near the place where it will be wanted. This is excellent management upon large and straggling farms; but on compact and smaller farms a central homestead is to be preferred.

These preparatory considerations having been settled, we proceed to enumerate some of those principles which should be kept in view in constructing our plan. The cost must be restricted within reasonable limits. The character of the farm and the kind and quantity of stock it is best fitted for are important considerations. The economy of labour and the comfort of the animals which have to occupy the buildings must also be consulted. The central position of the homestead may be deviated from in order to obtain a good supply of water for drinking purposes, or as a power. Where the water-supply is deficient, much may be done by collecting the water from the roofs in reservoirs.

The general form of farm-buildings should be rectangular. They usually consist of some three or four parallel ranges of roofed buildings, devoted to different purposes, and extending from north to south, so that both sides may receive an equal share of sunlight, and all may be protected from the east and west winds. The north ends of these parallel ranges join some important offices, which, passing from east to west, give the rectangular outline already insisted upon. The scale should be liberal and roomy, so as to ensure plenty of space for straw and roots; and the method of transit from one part to another should be carefully studied. The principle of internal arrangement is as follows:—The straw is the most bulky and most frequently required material in the homestead. The source of straw, therefore, or threshing machine, should occupy a central position, and the buildings for the accommodation of live stock should be arranged at a greater or less distance from the straw-barn, according to the quantity of straw the animals require.

The rick-yard should occupy the extreme north of the homestead, and if there is a gentle slope towards the barn, so much the better. There are two good reasons for placing the rick-yard in this position: first, it gives shelter from the north wind to the remainder of the buildings; and secondly, it is better for the corn, as in this exposed situation it comes sooner into "condition." In a line due south from the rick-yard, and occupying a central position with regard to the other buildings, we should find the barn containing the threshing machine; and continuing the line southward, past the machine, we ought to find ourselves in the straw-barn. On either side of, and parallel with, this main building are straw-yards and sheds for live stock, arranged with a view to straw supply; and other offices, such as implement and cart sheds, root-houses, and store-rooms, are placed in the most convenient situations. The corn-barn containing the machine is usually a two-storeyed building, and the granaries should extend as two wings eastward and westward from it. Thus we have established the position of the central barn, and the granaries running across at right angles to it will form a good screen from the north wind.

The following plan (Fig. 2) is adopted on an estate known to us, and the principles which have been observed in these excellent buildings are fairly illustrative of what has been advanced in these columns.

The *Barn* is usually a long rectangular building, one part of which is floored, and contains the threshing machine, while the remainder is open to the top. The first portion forms the upper and lower corn barns, and is situated next the rick-yard, while the open portion is known as the straw-barn. In the homestead of the Flemish Farm, Windsor, made to accommodate the stock and crop of 190 acres arable and 200 acres pasture land, the inside measurements were as follow:—

Upper barn	. . .	23 × 23 feet.
Corn (lower) barn	. .	23 × 23 ,,
Straw barn	. . .	49 × 23 ,,

At Thorney Farm, Cambridge, the barn accommodation for 400 acres arable land and 100 acres pasture are—

Upper barn	. . .	21 × 44 feet.
Lower (corn) barn	. .	21 × 44 ,,
Straw barn	. . .	21 × 49 ,,
Additional threshing room		20 × 23 ,,

Cattle Accommodation: Folds, Boxes, and Byres (stalls).—All three forms of accommodation are ordinarily used. Small folds are an excellent home for store and fatting cattle, but should be provided with plenty of shed-room, and with troughing to carry off the water from the roofs. At the Coleshill Farm, in Berkshire, the property of the Earl of Radnor, a shed runs the entire length, and provides shelter for four yards. The shed is divided into lengths of 17 feet each, and in front of each section is a yard 23 × 17 feet. Water is provided for each court, and feeding-troughs extend along the shed.

Boxes are suitable for fatting, rather than store cattle. They may be built as a double range, with a passage between, and under one roof. Suitable dimensions for each box will be 9 × 10 feet, and the bottom of each must be sunk about 2 feet below the surface of the ground. The boxes will be separated from each other by slip-rails.

The best arrangement for *byres* or *stalls* is a double row, the cows standing head to head, with a feeding passage between. A shed so fitted, 45 feet long and 32 feet wide, exclusive of the thickness of the walls, would provide accommodation for twenty cows. Each cow would have a "standing" of 4 feet 6 inches by 9 feet, with a passage behind her of 4 feet, and 6 feet for trough-room and feeding-passage in front.

Mr. Ewart thus writes upon *work-horse* stables. They should be well lighted, perfectly dry both above and below, have the means of preserving cleanliness at all times, and have perfect ventilation and means to regulate the temperature without subjecting the animals to direct draught. The proper length for a stable will be found by allowing 6 feet for every horse, and the width should not be less than 14 feet. Mr. Scott Burn, however, would in no case allow the width of the stable to be less than 18 feet.

The *calf-house* should communicate with the cow-house, and should be a roomy, well-ventilated building, divided into separate sparred cribs or hutches, each of which should be furnished with a trough and rack. The dimensions of these cribs will vary from 4 × 4 feet to 4 × 6 feet, or even 4 × 8 feet. Glass tiles, loop-holes, and half-doors should be all used in order to ensure a supply of light and air to the young animals.

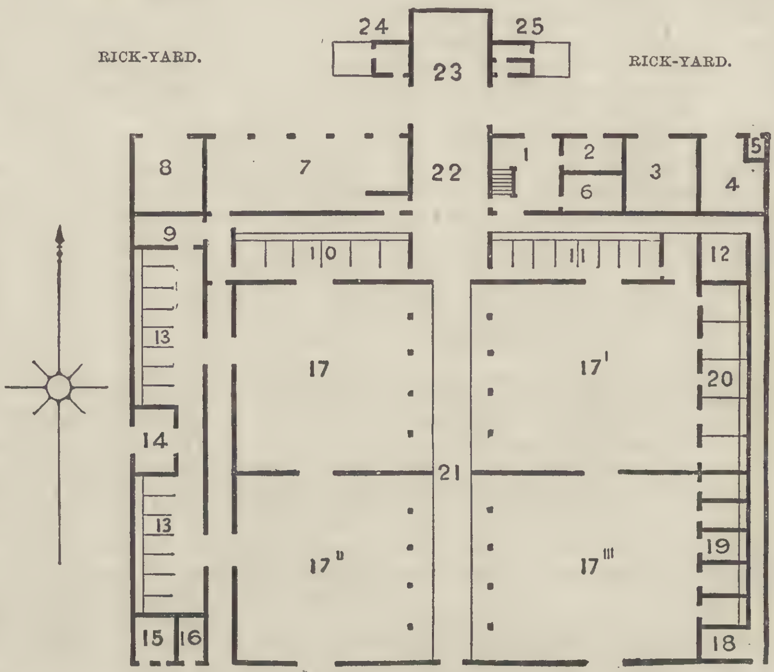


Fig. 2.—PLAN OF FARM-BUILDINGS.

1. Food-mixing room
2. Root-house
3. Engine-room and shop } With granary overhead.
4. Manure-shed
5. Privy
6. Boiler-house
7. Cart-shed } With granary overhead.
8. Implement-shed
9. Corn-room.
10. Fatting-stalls.
11. Cow-stalls.
12. Calf-house.
13. Work-horse stable.
14. Harness-room.
15 and 16. Loose boxes for stallion or foaling mare.
17, 17', 17'', 17''', fold-yards.
18. Loose-house, or turnip-house.
19. Pig-sties, with covered feeding-passage.
20. Boxes for cattle, with covered feeding-passage.
21. Sheds for cattle, with straw-barn overhead.
22. Threshing and dressing-floor.
23. Sheaf-barn.
24. Bull-house and yard.
25. Boar-house and yard.

The *granary* will vary in size with the area of the farm. Taking 20 feet as a constant and convenient width, 60 or 70 feet in length would give ample granary room for even a large farm.

To give any account of the remaining and less important offices already named in the list, and shown in the plan, would prolong the present paper beyond its proper limits, and we therefore leave such considerations, referring the reader for fuller information to Baily Denton's "Homesteads of England," Scott Burn's "Book of Farm Buildings," Stephen's "Book of the Farm," and Ewart's excellent little book, "The Agriculturist's Assistant." We conclude these remarks with the following approximate estimate as to the cost of buildings on farms of various sizes, supplied by Mr. Baily Denton:—

"Farms of 1,000 acres and upwards, of tillage and mixed husbandry, will require an outlay in house and homestead of £4,000 to £5,000.

"Farms of 500 to 1,000 acres, of tillage and mixed husbandry, will require an outlay, as above, of from £2,500 to £4,000.

"Farms of 200 to 500 acres will require, under similar conditions, an outlay of from £1,500 to £3,000."

In the most recent edition of Bayldon's "Rents and Tillages," a farm of 250 acres is supposed to require an outlay in house and buildings of £1,500. Such estimates will, we fear, be rendered scarcely applicable at the present time, on account of the unsettled state of the labour market generally, and of the building trade in particular.

THE END.

Cassell, Petter, & Galpin, Belle Sauvage Works, Ludgate Hill, London, E.C.

GENERAL INDEX TO THE COMPLETE WORK.

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